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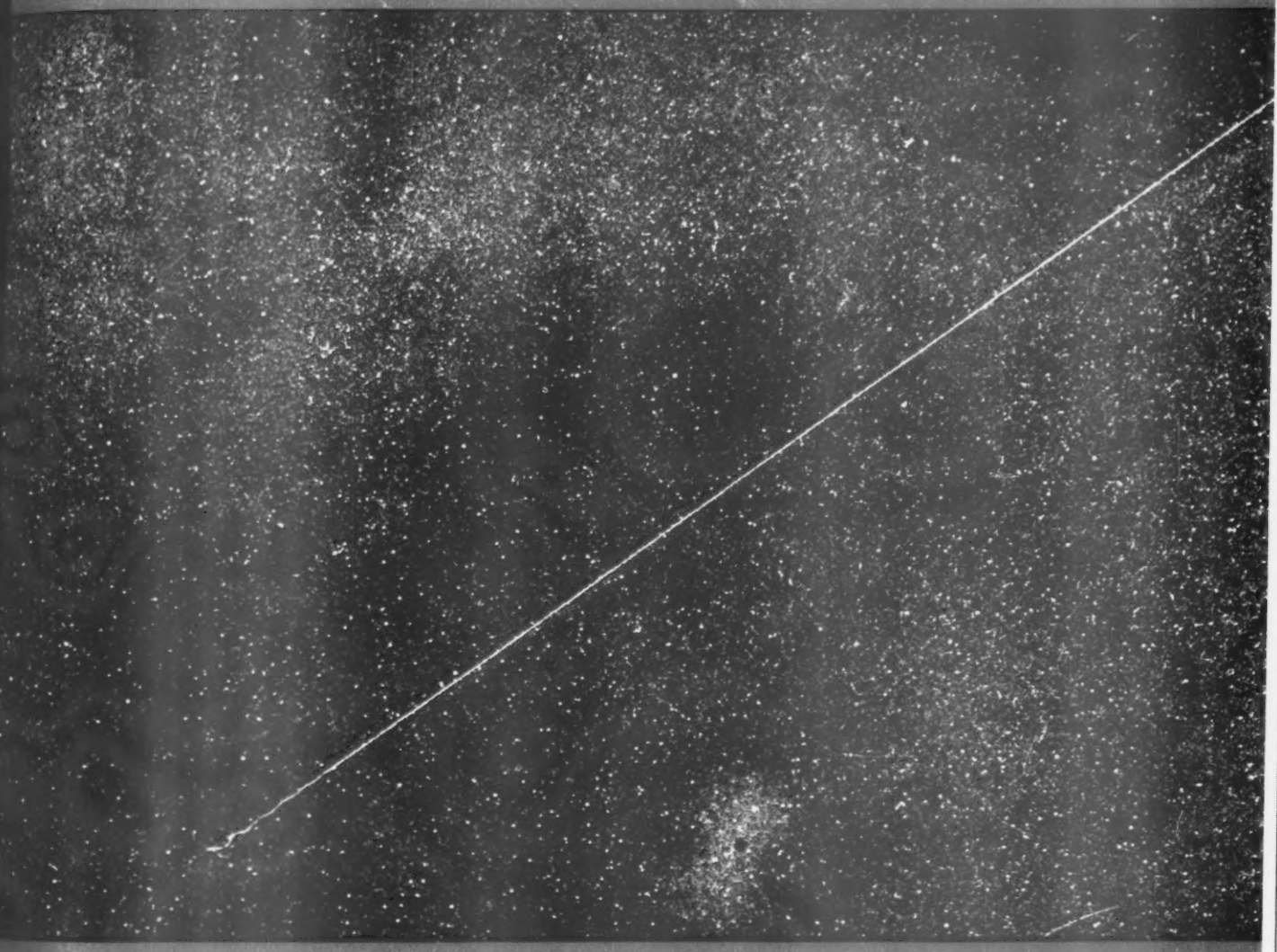

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SPACEFLIGHT

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The Russian Satellite "Sputnik."
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Editorial

It is inevitable that much of the present issue of SPACEFLIGHT should be devoted to the Russian satellite programme. This in no way detracts from the appreciation of the American effort; great work is being done there, but it is fairly clear that for the moment, at least, the most far-reaching developments are likely to come from the Soviet Union, for whose research workers no praise can be too great.

Progress is now being made at a rate quicker than ever before. One of an Editor's difficulties under such circumstances is to keep fully up to date. A periodical has to go to press sometime before it is actually published, and it is quite possible that some new major success will have been achieved between the writing of these words and the moment when the present issue is in our readers' hands. However, there is no way out of this difficulty, and it is hardly necessary to add that every effort is being made to include the results of the most recent work.

The title of our first article is "The Space Age is Here". Nobody can doubt this fact; the evidence is there for everybody to see. The amount of interest shown in the first Russian launching was pleasing; the Press, television and broadcasting services did a good job, even though it was discouraging to see that after the first week or two "Sputnik I" was gradually eased out of the newspaper headlines in favour of the usual sordid political wrangles which should now, surely, be out of date. "Sputnik II" also was satisfactorily dealt with.

In short, the faith of the early pioneers—Ziolkovsky, Goddard, Oberth, Cleator and the rest—has been justified. The flight of the first moon-rocket, even though an unmanned one, is imminent. If politicians all over the world can learn to sink their differences and start to behave in an adult way, the "Space Age" can indeed be a bright one.

PATRICK MOORE

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Our Cover

The Russian satellite "Sputnik" was photographed by the Australian Commonwealth Observatory at 19.37·5 hours Eastern Australian time on October 8, 1957.

The picture was taken by Mr. Kurt Gottlieb, research engineer of the Australian Commonwealth Observatory at Mt. Stromlo, near Canberra.

He used the University of Uppsala (Sweden) Schmidt telescope, by consent of the Swedish observer. Uppsala erected this station to make observations of southern constellations. The trail of the satellite was taken first but the exposure was then continued with the normal diurnal motion of the telescope to record stars in the background, in order to be able to measure the position of the trail in relation to the star. The sky was rather bright because of the moonlight and this tended to over-expose the plate. However, it was regarded as suitable for scientific measuring purposes.

The telescope is very fast and allows short exposure times essential for this type of picture. The telescope has a mirror diameter of 65 cm. (26 in.) and 69 in. focal length.

The Australian Commonwealth Observatory is one of the world's leading observatories. It attained major importance late in 1955 when its new 74-in. telescope was brought into use. It is the principal centre for astronomical and astrophysical research in the Southern Hemisphere and with the southern station of the observatories of Yale and Columbia Universities there, as well as Uppsala, is an international research centre.

Australia has also been playing an active part in recording the movement of the satellite. Australian scientists at Woomera, in the desert region of northern South Australia, began tracking the satellite on October 5. It was first picked up at 10.30 p.m. local time on October 5, when the man-made planet passed over Woomera.

Scientists worked around the clock with special equipment to track the satellite, operating on 20 Mc/s. and 40 Mc/s. Signals from the satellite have been recorded on magnetic tape. The records are being analyzed, and any interesting information will be provided to other scientific organizations throughout the world, it has been officially announced.

South-eastern Australia is one of the few land masses over which the satellite has been moving in the first days following its launching and millions of Australians have been watching its 5-minute progress across their skies each evening just after 7.30 p.m.

Opinions expressed in signed articles are those of contributors, and do not necessarily reflect the views of the Council of the British Interplanetary Society unless such is expressly stated to be the case.

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TO ALL MEMBERS

NOTICE OF THE SOCIETY

The B.I.S. Satellite Programme

Now that the first artificial satellites have been launched, there has at last been a general realization that space-travel will be an accomplished fact within the foreseeable future, and this has led to a sudden awakening of general interest. It is clearly of importance to study these first satellites as closely as possible. This would be desirable in any case, but is even more so in view of the fact that there is no guarantee that all information will be quickly released from official sources in Russia. Such information will certainly become available in time, but it may involve some delay, and it is essential for world-wide observations of the vehicles to be carried out.

In this programme the B.I.S., as the pioneer society of Great Britain, should and, indeed, must play a leading part. At the present time there is no well-knit organization, although such organizations have been formed within the British Astronomical Association (Radio and Electronics Section) and the Radio Society of Great Britain. The B.I.S. proposes to set up, at once, an organization to collaborate fully with the B.A.A. and R.S.G.B. workers, and to carry out observations under the auspices of the I.G.Y. Committee. As a first step it is proposed that the Yorkshire Branch observatory at Harlow Tower, Harrogate, shall be established as a satellite observation station. It is important that this should be supplemented by the efforts of individuals and groups in other parts of the country. This work comes into three categories:

1. *Visual observations*, already described in the Moonwatch publications. These can be conducted with inexpensive equipment, and will be useful, though it needs considerable skill to attain the co-ordination and the required degree of accuracy. Technical information and advice can be obtained from G. E. Satterthwaite, 31 St. James Road, Sutton, Surrey.

2. *Photographic observations*. These can be conducted by anyone who has the necessary equipment—and the enthusiasm. An ordinary Press camera, on a tripod and preferably with a metronome for time-marks, is adequate for the purpose. An accuracy of one-tenth of a degree of arc and one second of time is needed. This photographic programme is of vital importance—certainly more so than visual work. Here, perhaps, the scope for the B.I.S. is widest.

3. *Radio measurements* of signal strength on 20 and 40 Mc/s, and, if possible, Doppler measurements. Technical information can be obtained from K. C. Garner, Dept. of Aircraft Electrical Engineering, College of Aeronautics, Cranfield, Bletchley, Bucks., who is Co-ordinator.

For the moment, at least, the main function of the B.I.S. is to collect data for analysis. Such work must depend largely upon amateurs, simply because there are not enough professional stations or workers to deal with it. The Council is determined that the B.I.S. shall play a very active part in the present satellite research.

It is suggested that the organization will be made up of Branch centres, with a controlling centre in London working closely with other organizations and authorities. Success depends entirely upon the degree of response, and there is no time to be lost.

If you feel able to play a part in this programme, please communicate immediately with the Secretary of your local Branch; or if you are not near a Branch, with the main Headquarters in London (by letter, please —not by telephone).

Please consider this very seriously, though remember too that the programme calls for the devotion of both time and concentration. We hope to hear from you as soon as possible, giving details of your experience (e.g. in meteor studies or general astronomical observation, or radio or radar experience) and details of your equipment, if any.

Ephemerides, satellite observation notes, the Smithsonian *Bulletins for Visual Observers*, and other information will be sent out regularly to individuals or groups who wish to take part in these activities.

London's New Planetarium

The Zeiss Planetarium for London arrived on site on November 13, 1957; a total of 18 cases (three of which weighed over 1 ton each). It was driven from Surrey Commercial Docks in two huge lorries. The German engineers are now assembling the hundreds of parts which compose the instrument, and they expect to spend over two months on the task.—A. H. DEGENHARDT.

(Note: An issue in the near future will contain a full article on the Planetarium by Dr. H. C. King, who has been appointed Senior Lecturer there.—EDITOR.)

The Space Age is Here

By MAURICE ALLWARD

"The Space Age is Here." This was how one national daily newspaper headlined the news of the Russian satellite, and few readers of *Spaceflight* will have disagreed.

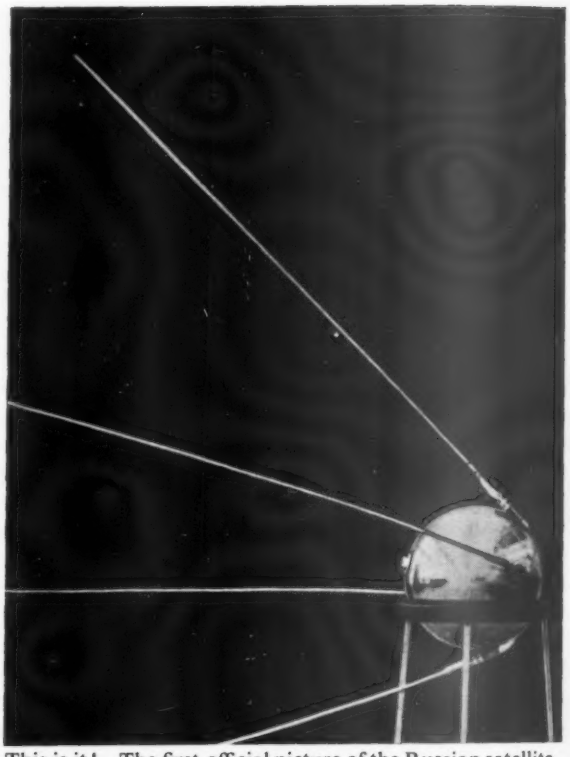
Admittedly, Ziolkovsky's historic paper on the subject of rocket motion of 1903, Goddard's liquid-fuel rocket of 1926, the German V2 and, more recently, the Aerobee and Viking high altitude research rockets, have all, in turn, been hailed as the "first steps" to interplanetary flight. But the Sputnik (meaning "fellow-traveller"), as the Russians called their satellite, was different. For years articles have been appearing at an ever-increasing rate on space travel. And, as the pattern of development slowly evolved, it became clear that the first rung in the technological ladder to the planets would, indeed, be the construction of a vehicle capable of attaining a stable orbit around our planet.

In his paper "The Artificial Satellite", read at the Second International Congress of Astronautics, London, 1951, L. R. Shepherd, then Technical Director of the B.I.S., stated: "The uses to which a satellite vehicle might be put are sufficiently numerous to justify considerable expenditure on their development. Their value as scientific research stations would be beyond measure." He continued: "*But the real value of the orbital vehicle lies in its importance as an essential springboard in the supreme adventure of interplanetary flight. This without doubt must be regarded as the main reason for our interest in the device, all other purposes being of secondary importance.*"

At the same Congress it was revealed that "one government had already announced its intention of pursuing the development of the satellite vehicle". This was confirmed in July 1955, when it was announced in Washington that the United States intended to establish small, unmanned, artificial satellites in space as a contribution to the International Geophysical Year.

From then onwards, the establishment of a satellite was obviously only a matter of time. Anticipation of the event could, therefore, have reasonably been expected by the world in general and by interested parties, such as the members of societies such as our own, in particular.

As it was, the historic announcement from Moscow on October 5 that "As a result of intense, large-scale research conducted by Soviet research institutes and design organizations, the world's first artificial earth satellite has been developed in the Soviet Union. On October 4, 1957, the first satellite was successfully launched from the U.S.S.R.", astonished everybody—some members of the B.I.S. in particular!



This is it! The first official picture of the Russian satellite, which the Russians call "Sputnik". It is seen here on a stand, some time before it was launched into outer space to whirl round the Earth at a speed of 5 miles per second

Without doubt the reason for this was not so much that a satellite had been launched, but that it had been launched south from Russia over Moscow, instead of south-east from Florida over the Atlantic! True, Professor Leonid Sedov had announced at the sixth International Congress, in Copenhagen in 1955, that the Soviet Union intended to launch satellites during the Geophysical Year. But, in spite of K. W. Gatland's reminder in the July 1957 *Spaceflight*, the writer confesses that, faced with the wealth of information released on the U.S. Vanguard project, he tended to overlook this, as probably did most other people west of the Iron Curtain.

After taking in the bare fact of the announcement, the Press was eagerly perused for further details. Then came a surprise almost as great as that of the satellite itself: its reported weight. The figures quoted varied from various sources, but averaged around 180 lb. At first the present writer was convinced that a decimal

This diagram of a model of the satellite which the Russians have launched into space, was recently published in the Soviet "Technology for Youth". Translations of Russian annotations are as follows, reading from top to bottom: Magnetometer; Mercury accumulator; Radio transmitter; Spring for detaching satellite from rocket; Explosive pin and rocket nose; the small diagram on the left shows the orbits of the artificial satellite, while the bottom diagram illustrates positions of the satellite in relation to the Earth (left to right) Night—invisible; Evening and morning—visible; Day—invisible

By courtesy of the United Press

point had got lost somewhere, but soon it became clear that the satellite did, in fact, weigh 184·3 lb. This is some nine times as great as the proposed Vanguard satellites and, remembering the latter's approximate 1,000-to-1 ratio of the launching-to-satellite weight, it became apparent that the Russian launching vehicle must have been an impressive monster weighing around 100 tons. This was confirmed by Moscow, who announced that it was a three-stage vehicle powered by a first-stage motor delivering 264,000 lb. thrust and burning out at about 8,500 m.p.h. The second stage incorporated a 79,000-lb. motor burning out at something over 12,000 m.p.h., and the third had a relatively small motor, designed to give the tangential push required to establish the satellite in its orbit.

The Sputnik was thus very much bigger than most space-travel enthusiasts had thought practicable for this important first step towards interplanetary flight. Most recent design studies had, primarily on the grounds of economy, been concerned with the smallest possible orbital vehicle. America's Vanguard itself is expressly designed to the minimum size that can reasonably be expected to establish an instrumented satellite.

Although the satellite was fitted with a comparatively simple radio transmitter, the payload was obviously sufficient to allow complex instrumentation in later vehicles and, perhaps, the carriage of animals or a television camera.

The next big surprise regarding the Sputnik concerned its orbit. The first point to note was that, lying some 65 degrees off the equator, little or no assistance will have been attained from the rotation of the Earth. In the case of the proposed orbit of the Vanguard (20 degrees to the equator) this bit of "free speed" is estimated to be worth about 900 m.p.h. With the Vanguard the Americans are hoping for an orbit with 200 and 800 miles as its upper and lower limits; to achieve even these limits extremely close control will be required over the burnout speed of the satellite and its final positioning in relation to the surface of the Earth. According to the circular issued by the British Astronomical Association on October 15 (Circular No. 390), the height of the Sputnik seemed to vary between 603 miles and 118 miles, indicating either a "fluky" first attempt or else exceptionally well-developed control techniques. That the former was, perhaps, incorrect was indicated by an announcement from Moscow, at 12.15 G.M.T. on October 5, including the following details of the orbit:

"At 12.04 Moscow time the satellite's position was in the area of the city of Johannesburg. Since the moment of its passage over the Moscow area at 01.46 on October 5, it has circled the Earth about 6½ times. The period of its orbit round the world, according to precise assessment, lasts 96·2 minutes. The radio transmitters are working uninterruptedly . . . The appearance of the satellite is expected to-day in the areas of the following cities (Moscow time): Detroit, 16.30; Washington, 16.31; Magadan, 17.52; Calcutta, 19.16; Ulan Bator, 19.23; Karachi, 20.54; Alma Ata, 20.58; Baghdad, 22.32. On October 6: Yakutsk, 00.25; Prague, 01.49; Riga, 01.51; Moscow, 01.52; Oslo, 03.27; Rangoon, 05.28; Bandoeng, 05.35; Leningrad, 06.49; Moscow, 06.50; Bombay, 07.03; Damascus, 08.34; Manchester, 10.05; Paris, 10.06; Rome, 10.09."

Such precise times meant that either the Russians had an extremely efficient orbital computer available—or that so confident were they of the control techniques that they had worked out the times *before* the launching. This latter suggestion seems only slightly less incredible than the former. Whichever was the truth, it was obvious that the world was witnessing one of the most spectacular scientific advances to date. The "bleeps" from space told the world that Russia's satellite programme, not America's, was the vanguard; but before long, it is certain that more satellites will be sent up from both East and West.

The First Days of Sputnik I

The launching of Russia's first space-satellite was an historic event. It is therefore of interest to have an historical record of it, covering the visual, radio and radar observations made at the time. We are very glad to be able to print reports from those directly concerned—from the Royal Observatory, Edinburgh, where some of the first visual observations were made; from the Mullard Observatory, Cambridge; from the B.B.C. listening post at Tatsfield; from Jodrell Bank, and from the radio amateurs. It is hoped that these reports will give a balanced picture of the feverish activity which went on during "the first few days".

EDITOR.

VISUAL OBSERVATIONS OF THE FIRST RUSSIAN SATELLITE ROCKET

By V. C. REDDISH, B.Sc., Ph.D., Royal Observatory, Edinburgh

At half past five on the morning of Wednesday, October 9, we made our first visual observation of the third stage rocket which had carried Sputnik I into its orbit and was then circling the Earth some 650 miles behind the satellite.

Positions given in Russian broadcasts had enabled us to predict an approximate path across the sky; with theodolite and chronometer ready, a watch was kept high in the north-east. The predicted time for the satellite was 05.28 hours, the rocket a little over two minutes later. As the seconds ticked past 05.30 hours a feeling of disappointment began to grow. Then suddenly from behind the thickening clouds flashed a point of light—as bright as Vega, one of the brightest stars. Moving quickly across the sky, in twenty seconds it had gone. It was visible just long enough to enable a measurement of time and position to be made.

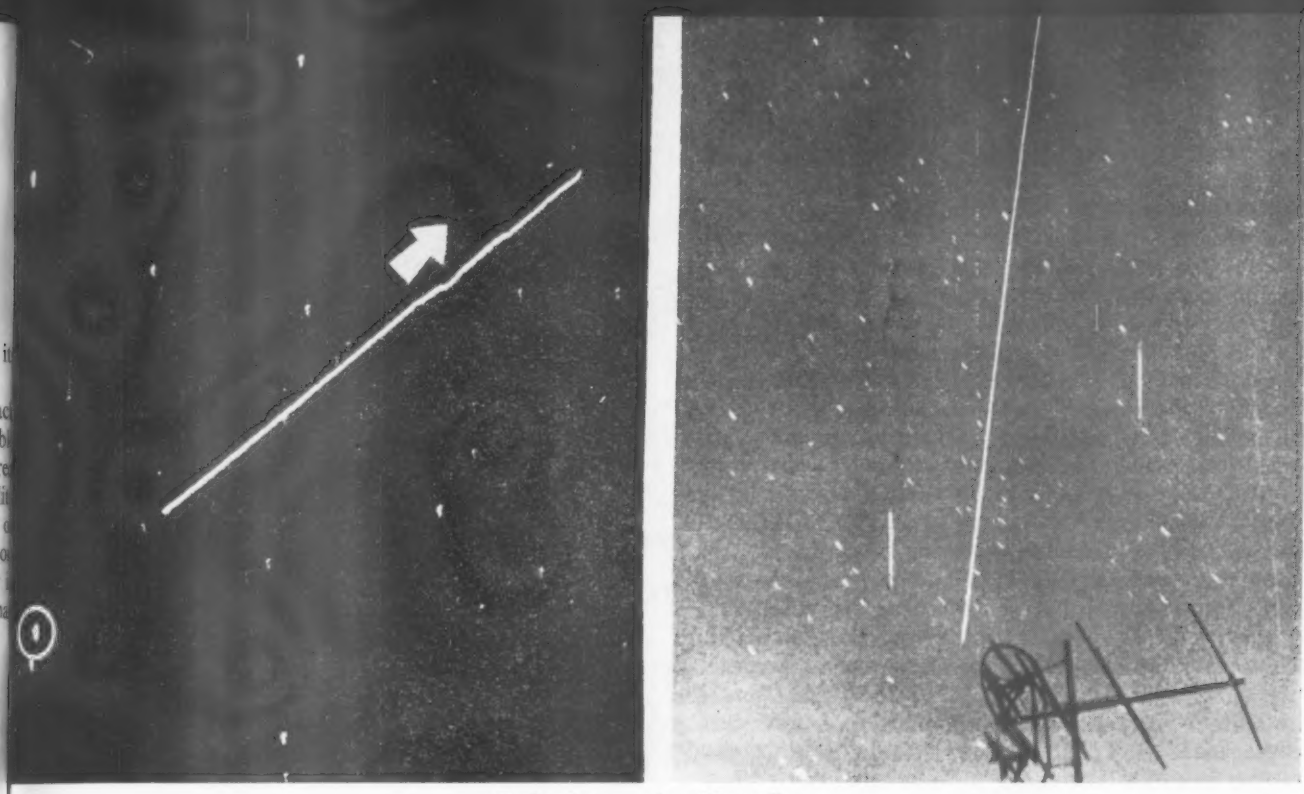
Two strong impressions remain. The brightness was much greater and it was moving across the sky faster than expected. We now know that it was little more than half its maximum height at the time, and this accounts for its apparently greater motion across the sky (more than the diameter of the Moon each second). Generally speaking, when it is seen at high altitudes above the horizon it is nearer and apparently moving faster than when seen at low altitudes. At the evening passages in Britain it is much nearer the Earth than in the morning ones, and apparently moving faster still. To be fully illuminated by the Sun it must be seen within about an hour and a half of sunrise or three-quarters of an hour of sunset at the time of writing, but these times may change as the orbit alters. It is unlikely to be so bright as to be visible in daylight even at its nearest.

It moves so quickly across the sky that unless its track is known accurately beforehand it is almost impossible to find it by telescope, the large area of the sky covered by the naked eye giving it an advantage. The satellite itself is not visible to the naked eye. A good pair of binoculars or a small telescope with *low* magnification are the most useful instruments to use to search for it at the approximate times often given in the national press or on Russian broadcasts.

[*Note: The rocket has now, of course, fallen.—Editor.*]

Elmendorf Air Force Base, Alaska: U.S.A.F. photographers stationed here spotted and photographed the Russian satellite Sputnik as it whizzed across the skies at approximately 5.03 a.m. (Alaskan time) October 8th. Sputnik's speed was so great that individual pictures could not be obtained. The time exposure reveals the satellite as a brilliant streak of light against the blackened sky. A top Russian scientist visiting Yugoslavia who claims to have had a personal part in launching Sputnik told newsmen October 9th that the earth-circling satellite carries "complete telephoto equipment"

By courtesy of the United Press



Early photographs of Sputnik

By courtesy of the United Press

OBSERVATIONS OF SPUTNIK I MADE AT THE MULLARD RADIO ASTRONOMY OBSERVATORY, CAMBRIDGE

By Martin Ryle, F.R.S.

On the morning of Saturday, October 5, we met to discuss the possibility of adapting a radio telescope normally used for plotting radio stars, to observe the first Russian satellite. As far as we knew, no suitable apparatus existed elsewhere in the country, and it seemed clear that both visual and radar observations of the satellite would be extremely difficult unless a reasonably good prediction of its future position could be made from observations of its radio transmissions.

During Saturday, we modified one of our receivers for the 40 Mc/s. transmission, and made successful observations during Saturday night. On the following day we installed a more accurately surveyed interoferometric aerial system, and a second receiver was arranged to measure the Doppler shift of the frequency due to the satellite's motion.

Despite their very hurried assembly, both systems successfully outlasted the satellite's batteries!

The first system allowed the passage of the satellite across a system of "grid-lines" to be plotted, and in the second the track could be found independently from measurements of the minimum slant range. From the ground track and heights found, it was possible to provide reasonably accurate predictions of the satellite's position for 24 and 48 hours in advance, and measurements of the change of the orbit have made possible a first estimate of the air density at a height of 200 kilometres.

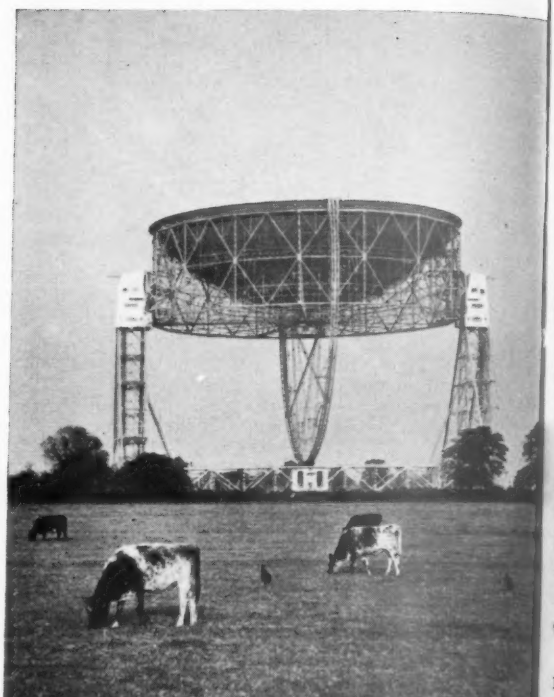
FIRST OBSERVATIONS FROM JODRELL BANK

By a Member of the Research Team

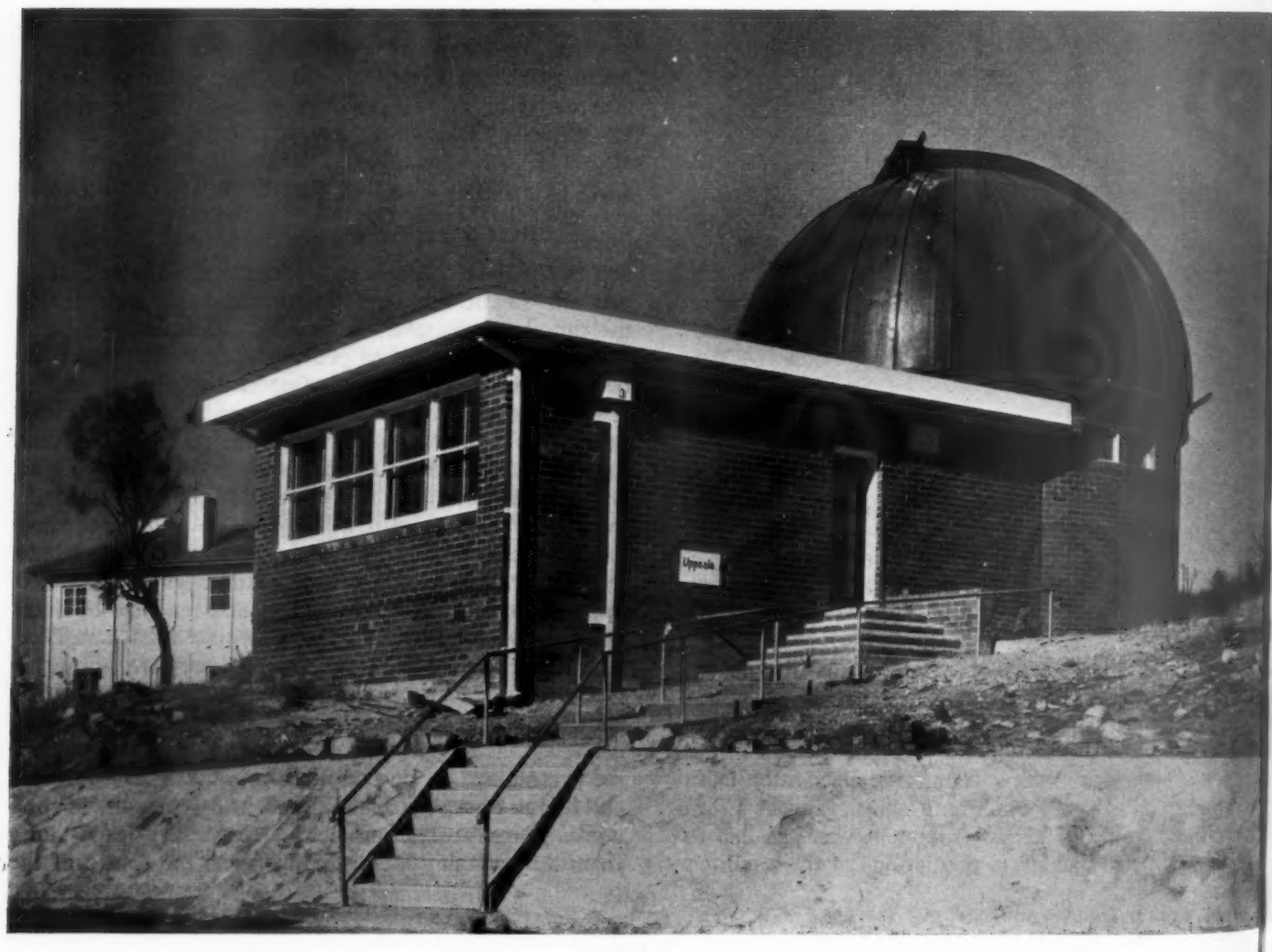
The 250-foot steerable radio telescope at Jodrell Bank was still in the hands of the construction engineers at the time of the satellite launching. A number of basic radio frequency tests had previously been made upon it, but these were in the nature of polar diagram determinations using the direct radiation from the cosmic radio sources. The handing-over date was still in the distant future, and no radar equipment was installed on the structure; indeed, the nearest was a quarter of a mile away, and this was of relatively low power. According to press reports at the time, a somewhat heated debate took place, in which the consultant engineers claimed that the structure was fully usable and ready to operate, while they alleged that the scientific staff consisted almost entirely of young students who were not competent to construct the equipment. The scientific staff, on the other hand, argued that the telescope was *not* ready, as much of the control and computing equipment remained to be coupled up, various large girders still had to be replaced, and the electric wiring and cabling consisted only of a number of temporary leads slung from the swinging laboratory beneath the centre of the

bowl structure down to the central bearing over 100 feet below. These cables, upon which the life-blood of the telescope depended, were completely unprotected from the ravages of the weather and of the giant telescope itself when it commenced to twist and turn. Indeed, in the hectic days to follow, the cables were on at least one occasion sliced through by the remorseless motion of this parent structure. A further minor complication arose from the fact that the telescope was teeming with painters; everywhere one trod the paint was wet, and the whole edifice was festooned with planks and gantries to facilitate the beautifying of the beast.

The scientific staff took up the engineers' challenge; long transmission lines were run from the distant transmitters up to the focus of the bowl, feverish work was crammed into the apparatus, never designed for the detection of so small an object at so great a range, and in a very few days, with the most meagre equipment and the maximum of improvisation, the telescope obtained the first radar echoes from both the rocket and the satellite. Thereafter a number of further observations were made in collaboration with the radio "bleep"



The Jodrell Bank 250 ft. radio telescope
Reproduced by courtesy of Crewe Chronicle and Geoffrey Turner



The station at the Australian Commonwealth Observatory at Mt. Stromlo, near Canberra, from which the photograph was taken (*see* "Our Cover", *p. 194*)

measurements both at Cambridge and Jodrell Bank, and the orbital computations of the Herstmonceux Observatory. The rocket was shown to be gaining on the satellite, and its own orbit was mapped. Finally, for want of sleep and for the sake of the science for which it was designed and intended, the telescope was handed back to the engineers with the option of using it again at short notice should further observations be urgently required.

Three weeks after the satellite was launched, the batteries feeding the satellite's own transmitter also went to sleep, and prevented further radio observations throughout the world. Apart from visual sightings the satellite was lost unless radar could again detect it. This would have included the Russians themselves, for a telegram arrived at Jodrell Bank post-haste from the Soviet Academy of Sciences asking if the telescope could be used to fix the rocket. Within a few hours the fix went back, giving the exact range and time of transit over the meridian—figures which confirmed exactly the British computations of the orbit but which were significantly different from the Russians' own predictions.

The work at Jodrell Bank was not confined to the radar observations, as a small team hastily improvised aerial systems and receivers soon after the launching to study the "bleep" signals on a frequency of 40 megacycles. From Jodrell Bank came the first reports that the satellite was spinning, and a large amount of useful data was collected on the signals from the object itself.

RADIO OBSERVATIONS OF THE SATELLITE

By H. V. Griffiths, F.R.A.S.

Engineer-in-charge, BBC Measurement and Receiving Station, Tatsfield, Surrey.

The BBC station at Tatsfield undertakes, among its other regular duties, the measurement of the carrier frequencies of all BBC transmissions on medium, high and frequencies and on v.h.f., the identification of interfering and other foreign broadcasts, radio relaying for BBC programmes and news listening, and observations for the International Geophysical Year programme. Immediately the news of the successful launching of an Earth-satellite was released by Moscow, a watch was set for transmissions from the satellite and transmissions were heard first on 20·005 and 40·002 Mc/s. from 00.15 GMT on Saturday October 5. The satellite signals then took the form of regular pulses (or "bleeps") of the carrier frequencies, the pulses being interleaved on one frequency and then the other so that, listening to either frequency, the repetition rate of the pulses was 108 per minute. This repetition frequency slowly increased in subsequent orbits of the satellite and the mark-to-space ratio also altered, suggesting that there was a simple form of telemetering controlling the pulses, and possibly indicating the internal or external temperature for scientific purposes.

The pulses were replaced by continuous carrier transmissions for a period about 19.35 GMT on October 6th, thereafter becoming more spasmodic and finally reverting altogether to the uninterrupted carriers only. Observations have since been continued at Tatsfield in the audibility period during each orbit, and numerous measurements have been carried out. The Doppler effect, whereby the received frequency of an object emitting electromagnetic (or other) waves is increased if the source of the radiation is in motion towards the observer and is conversely decreased if the relative motion is that of recession from the observer, has been regularly measurable. From this "Doppler shift" (which is a common phenomenon in astronomy and has important uses) the slant-range of the satellite has been derived. Other data can also be obtained from it, including the velocity of motion relative to the observer, given that the angle between that motion and the direction of the wave-front is known, and the height or distance from the satellite's zenithal position, if either one of these be known.

The provision in the U.S.S.R. satellite of transmitters on 20 and 40 Mc/s. has enabled radio propagation conditions from and through the ionosphere to be compared on these widely different frequencies. Much will be gained from patient analysis of world measurements of reception of the satellite; there is little doubt that man's knowledge of the upper atmosphere, particularly with regard to its density and degrees of ionization, will thereby be improved and extended. For this reason, field-strength and fading records, frequency measurements, precise times of reception and some directional characteristics of the satellite signals observed at Tatsfield will all be of probable utility.

OBSERVATIONS BY THE B.A.A. AND THE R.S.G.B.

By John Heywood, F.R.A.S.

Director of the Radio and Electronics Section of the British Astronomical Association

Since the launching of Sputnik I, a makeshift organization has been inaugurated. The results of this work have shown that it is possible for the amateur to obtain information which is of value. Thus a joint organization by the British Astronomical Association (B.A.A.) and the Radio Society of Great Britain (R.S.G.B.) has been formed by the I.G.Y. Committee. Although the network was not intended to function until November 6, it was expected that it would be operating fully by Sunday night and yet contribute to the early measurements on Sputnik II.

The satellite Sputnik I was recorded on tape for the first few days by Hyde at Clacton. It was recorded on a double pen undulator by Roberts (R.S.G.B.) at Shropshire, the second pen in this case being used to provide time marks.

At Clacton, Hyde conducted a series of field strength measurements with aerials in different orientations and polarizations. These lasted into the second week and we were pleased to note that our deduction of elliptical

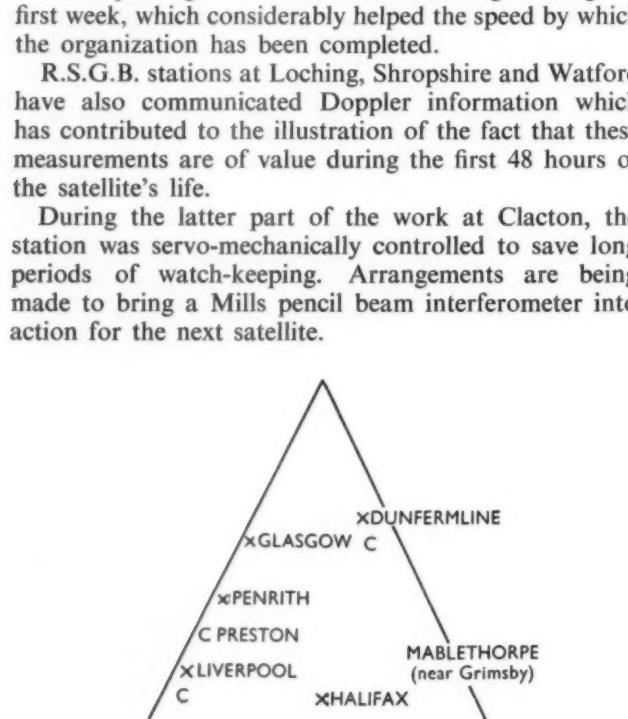
polarization was in fact correct. Similarly, a considerable amount of information on the ionosphere was obtained, and it is hoped that this work will be used as a "comparative" device at Cambridge. On a preliminary inspection it was thought that these characteristics would show a slightly slower rate of toppling than that given elsewhere. Bridged magnetic tape and pen recordings were kept during these observations.

The measurement of Doppler shift has also been successful. A 17-year-old sixth former, P. Goodhart, obtained a series of excellent slopes. Much thought was given to this problem by members of the Department of Telecommunications, Norwood Technical College, where a number of different pieces of apparatus were developed, some successful, others not—a private "not" has been written on the latter so that amateurs can participate even by experiment and so obtain information which in the final analysis may be of use only to themselves!

I was privileged to observe at Cambridge during the first week, which considerably helped the speed by which the organization has been completed.

R.S.G.B. stations at Loching, Shropshire and Watford have also communicated Doppler information which has contributed to the illustration of the fact that these measurements are of value during the first 48 hours of the satellite's life.

During the latter part of the work at Clacton, the station was servo-mechanically controlled to save long periods of watch-keeping. Arrangements are being made to bring a Mills pencil beam interferometer into action for the next satellite.



C Indicates Communication Links

× Indicates Doppler groups

⊗ Controlling Centre

Goodhart, Hyde and Roberts have all experimented successfully with obtaining a Doppler shift from the recordings made on magnetic tape.

At the same time, if ionospheric data are to be obtained, it is necessary to know the height daily, and one or two scattered Doppler shifts are always of use in this connection.

Thus the organization depends on a number of groups obtaining Doppler shifts during the first 48 hours of the satellite's life, and then arrangements being made to record (1) the telemetred data, and (2) the field strength.

Arrangements have been made to co-ordinate and abstract these data at Norwood Technical College, and it is hoped that the amateur will be encouraged to further scientific work, as will the professional benefit by his efforts.

The B.A.A. Radar and Electronics Section was fortunate to be represented at two or three critical points in the professional field, and the information obtained from these members enabled us to produce a very satisfactory report on amateur work in this field. We extend our thanks to them and to their employers who have extended to them, and to myself, every courtesy.

THE RUSSIAN "MOONWATCH" PROGRAMME

Some details of Russian arrangements for visual tracking of Earth satellites have been given by Dr. A. G. Masevich. The controlling body is the Astronomical Council of the Academy of Sciences of the U.S.S.R., and it seems that the equipment is very like that planned for the American programme. Telescopes with an aperture of 50 mm. and a magnifying power of 6 are to be used, giving a field of almost 11 degrees; the firm mounting of these instruments is emphasized. They can also be used for visual recording of meteors, a task which is still useful, though in these days somewhat overshadowed by radar methods of meteor study.

The Soviet authorities have established a fully co-ordinated programme, and many observing stations have been set up all over the U.S.S.R. The total reported by Dr. Masevich is 68. During observations, precise time signals will be provided by broadcasting or telephone, and after the observation has been made the exact position of the satellite at the moment of recording is plotted upon a star chart—the famous Bečvár stellar atlas being recommended for this purpose. It is expected to determine the position of the satellite to within half a degree, and the time to within half a second, though twilight observations will lead to lower precision owing to the lesser visibility of comparison stars.

The Russians emphasize that their programme can also be used to track the American satellite when this is launched, provided that the orbit carries the vehicle within observational range and sufficient advance information is given. They also stress that they are very ready to give full information to all other "Moonwatch" teams who wish to take part in the tracking programme.

BLEEP! By "Ursus"

The launchings of the first Russian satellites or Sputniks (also commonly termed Bleeps or, on occasion, Blips) have certainly caused world-wide interest, and comments have not been lacking. We may perhaps be forgiven for devoting a few lines to some of the less famous aspects of the new project.

On the whole, the National Press covered the launchings adequately and well, which supports the contention that as a class, reporters are a much-maligned race. There were some curious comments here and there, but even *The Times* gave the Sputnik I launching two half-columns, second only in importance on its main news page to some riots in Central Europe and the political squabbles about the Bank Rate. The *Daily Mirror* got off on the wrong foot, since news of the satellite was relegated to 23 lines on the back page next to the weather forecast, while the main front news page carried the immortal headline, in large black type, "Parson, 67, and Girl, 19, In Hiding—They Wed To-day!" However, the *Mirror* made amends later, and altered its subtitle to "The Biggest Daily Sale in the Universe." (Martian papers, please copy.)

No modern development in space exploration would be complete without a suitable comment from the Astronomer Royal, Dr. R. van der Riet Woolley. It might have been thought that the cry of "Bilge!" had been answered by a cry of "Bleep!"—but not a bit of it. Questioned as to whether the satellite had made him change his views, he replied in the negative, and in turn asked "How would you like to be up in that thing?" In a B.B.C. sound broadcast he stated that his head was "bloody but unbowed". Later he hedged somewhat—according to Press reports—by taking a leaf out of the late Professor Joad's book, and saying "It depends on what you mean by utter bilge," though he was also of the opinion that it is "a frightful waste of public money".

It may be suggested, by those of lesser eminence, that Dr. Woolley has gone some way towards disproving Judge Washburn's old dictum that "it is impossible always to be wrong". However, the observatory of which he is in charge —Herstmonceux—achieved immortality in its own way. Since the first launching was an epoch-making scientific event, it was not unnatural for inquiries to be addressed to Herstmonceux, which is supposed to be the fountain-head of British astronomy. Unfortunately the Russians had been awkward enough to launch their vehicle on a Friday evening, and this was the signal for Herstmonceux to close down for the week-end. Press statements indicate that the only information given to the journalists was to the effect that members of the Observatory staff work a five-day week!

We must admit that on this occassion even Dr. Woolley was quite outshone by the United States Chief of Naval Operations, Rear-Admiral Rawson Bennett. His comment was straightforward: "The satellite is a hunk of iron almost anyone could launch." Other American reports indicated that United States scientists could have lauched a satellite long ago if they had really wanted to, and President Eisenhower described it as "a ball in the sky". Later on, however, Mr. Dulles admitted that in some fields there was just a chance that the Russians were a little ahead of the Americans, even though, according to the *Sunday Times*, Professor Isidor Rabi, chairman of the President's Science Advisory Committee, stated that "of course there's not so terribly much science in Sputnik".

Things at Cambridge (England) more than made up for the amiable doze of Herstmonceux, and the observers did splendid work under very difficult conditions. However, it is understood that one published orbit was slightly in error, due to the fact that those who computed it forgot that the Earth's surface is curved. When the curvature was taken into account, things were much better. . . .

This brings us at once to the Flat Earth Society. Members of this learned organization are, like Dr. Woolley, quite unbowed. They recognize that the satellite can at various times be seen from most of the Earth, but they consider that the world is shaped like a gramophone record, so that the satellite is describing a circular path much in the manner of the needle when a record is being played. On the other hand, members of the German Society for Geophysical Research, who believe the Earth to be the inside of a hollow sphere, are strongly of the opinion that the Sputniks do not exist at all, and this is confirmed by Professor Varela Cid, of Lisbon (professor of aerodynamics), who was reported in the *Observer* as saying that "the artificial satellites do not exist, and the whole world has been bluffed by Soviet propaganda".

Oddly enough the Flying Saucer enthusiasts have been strangely silent, though in all fairness it should be pointed out that the annual Saucer Season does not generally start much before Christmas. However, various "landings" of satellites have been reported, and several worried folk have taken out large insurance policies against the risk of being hit on the head by bits of descending Sputniks. One report from Clifton, New Jersey, told how the police received an anguished call from a citizen who complained that there was a satellite in his garden. Naturally they investigated, and found a large sphere hanging in a tree. In turned out to be a basket-ball, with "upski" written on the top and "downski" on the bottom.

The ascent of the space-dog Laika caused more discussion. One society contacted the Health Ministry, asking what quarantine regulations would be applied if the dog happened to land in England. Of the many protests from animal-lovers, most were quite sincere; but one delightful piece of unconscious humour appeared in a Somerset paper, in which a writer commented on the hideous cruelty of the Russians, and in the next breath admitted that he enjoyed stag- and fox-hunting. . . .

It is also said that a Japanese agency which has been selling plots of land on Mars has been doing a roaring trade, while children's space-suits, ignominiously ousted last year by Davy Crockett outfits, have come back into their own. At present, however, it is perhaps best not to go more deeply into these and similar weighty matters.

By courtesy of Mirror Features

Russia's Second Satellite

By KENNETH W. GATLAND, F.R.A.S.
Vice-Chairman of the British Interplanetary Society

An appraisal of the techniques necessary to establish half a ton of research equipment in orbital motion round the Earth.

The "scientific break-through" that enabled Russia to launch first an artificial satellite of 184 lb. and then a fully-instrumented biological laboratory of 1,120 lb.—more than fifty times the weight of America's much publicized Vanguard—has resulted in a great deal of speculation both here and in the United States.

Exactly how was this achieved? As regards Sputnik 1, it is easy enough to see that payloads of this order might fairly easily be established "in-orbit" if an I.C.B.M. had been used as a booster. If we assume the same ratio of payload to launching weight as Vanguard, we find that for every pound placed in the orbit, 1,000 lb. of propellant and structure are required in the launching vehicle.* Using this same ratio, we arrive at the conclusion that the launching rocket of Sputnik I must have had a take-off weight of at least 80 tons. In other words, we might consider the launching vehicle of the first Russian satellite as a step-rocket approaching the performance of the Convair Atlas, an I.C.B.M. designed to carry an H-bomb 5,000 miles, but with the warhead replaced by a third-stage rocket with the satellite enclosed in its nose. This agrees with the earlier Russian claim to have successfully tested an I.C.B.M., and it would be reasonable to conclude that one of their prototypes had been adapted as a satellite launching vehicle. This would be a logical development—the sort of thing the Americans themselves might have attempted had their own ballistic missile programme been further advanced.

But what can we say about Sputnik II—six times heavier than the first Russian satellite?† The London *Daily Telegraph* even went so far as to suggest, in a Leader, that the whole thing might be deliberate hoax. The events of the past weeks, however, had resulted in a great deal of respect for Russian science and, by and large, the claim to have placed in orbital motion round the Earth a fully equipped research laboratory containing a living creature—a Husky bitch called Laika—was taken with due seriousness by Western scientists.

The official *Tass* announcement of the launching on November 3 gave the following details: "On board the second artificial there are: apparatus for studying solar radiation in the short-wave, ultra-violet and Röntgen region of the spectrum; apparatus for studying cosmic rays; apparatus for studying temperatures and pressure; a hermatically sealed container with an experimental animal—a dog—inside (it being air-conditioned and having a supply of food and instruments for studying living functions under cosmic space conditions); and measuring apparatus for transmitting various scientific observations to the Earth.

"Two radio transmitters are working on frequencies 40·002 and 20·005 mc/s. (wavelength about 7·5 and 15 metres). The total weight of all the above apparatus, the experimental animal, and the power supply is 508·3 kg. (about 1,120 lb.). According to observation data the Sputnik was given an orbital speed of about 8,000 metres per second. According to calculations which are being made more exact by direct observations, the maximum distance of the Sputnik from the Earth's surface is over 1,500 km. (about 935 miles). The time of one complete circuit is 1 hour 42 minutes. The angle of inclination to the equator is approximately 65 degrees. . . ."

The question of how half a ton of research equipment was got into a satellite orbit, with an apogee of 1,000 miles, is likely to be the subject of debate and speculation for some time to come, for clearly the launching vehicle must have had a performance at least equal and possibly superior to the Atlas. Indeed, if one considers the present state of the art—small H-bomb warheads, high megaton yield, etc.—this rocket, if used as an I.C.B.M., would appear to exceed military requirements for point-to-point H-bomb delivery. There is, of course, the possibility that this rocket was developed from the outset exclusively as a satellite launching vehicle, but this is unlikely. It is much more logical to assume that, at least in the early development stage, it was a military project, having as its goal the delivery of an H-bomb warhead over perhaps 5,000 miles.

At the time of its inception, perhaps four or five years ago, it must be remembered that H-bombs were exceedingly cumbersome. Indeed, it does not appear to be generally known that Convair's Atlas I.C.B.M. was originally twice the size of the actual development model currently undergoing test at Cape Canaveral. The proportions of the missile, as originally conceived, were in fact closer to those of a spaceship than a military rocket. Fully fuelled for take-off, it was estimated the missile would weigh over 200 tons. To lift this enormous bulk, seven rocket engines each of 125,000 lb. thrust would be required for the first stage alone, the whole battery developing no less than 20 million horse-power at burn-out.

* Vanguard has a launching weight of 22,000 lb; the 20-inch instrumented satellite weighs 21.5 lb.

† Taking the Russian announcement at its face value, i.e. that the figure of 1,120 lb. is accounted for purely by "apparatus" and does not include the empty carcase of the 3rd stage launching rocket.

Faced with a project of this magnitude, a Pentagon missile survey committee in 1953 proclaimed that it was incapable of practical realization. Even the most enthusiastic rocket engineers expressed doubts that the project could be a feasible engineering proposition within ten years and, at that, it would have been a fabulously expensive device to produce and operate. Once built, it was doubtful whether the missile would be sufficiently accurate over the great distances demanded of it.

Despite these objections, the U.S. Air Force placed study contracts with Convair which kept the project in being throughout 1954 on a budget of less than a million dollars. It had a low priority and was aimed at producing a weapon "in one or two decades."

The break-through came when American physicists produced a light-weight H-bomb, which immediately halved the rocket's take-off weight without any compromise in performance. Instead of seven rocket engines, only three were now required. Moreover, the megaton yield of the fusion-type warhead was so great that the rocket's accuracy was much less critical; because if the warhead fell within a 20-mile circle, this would be adequate for the complete destruction of a target.

In view of the American experience, the question might now be asked whether the Russians met the same initial difficulty in their I.C.B.M. programme but, unlike the Americans', accepted the challenge of developing a "super-rocket". Could this giant rocket have been the basis of the vehicle that launched Sputnik II?

At the same time, it is extremely unlikely that the take-off weight would have approached the figure of 500 tons one arrives at by using the Vanguard payload weight/launching weight ratio. First, the much larger rocket would permit a better ratio of propellant to structure, and second, according to a Russian spokesman, "new sources of power" were employed—presumably rocket fuels of very high specific impulse. What these fuels are is, of course, a matter for conjecture but presumably they would be something like pentaborane-oxygen or hydrazine-fluorine. These more exotic propellants, which have only been produced in lesser quantities in the West, necessarily burn at high temperatures and to use them the Russians must have made great strides in rocket motor design and construction.

With the development of a light-weight fusion-type warhead in Russia, work may have begun on a second (and smaller) I.C.B.M. project similar to Atlas, which ultimately became the launching vehicle for Sputnik I. Meanwhile, instead of cancelling the earlier project, development was continued, with the result that the much larger step-rocket provided a ready means of launching heavy satellite payloads.

At least that is one theory. Alternatively, one might surmise that the Russians have included the weight of the empty third stage rocket in the payload of Sputnik II. Whether or not the full story will ever be known outside the U.S.S.R., only time will tell.

The First Vanguard Launching

Following the Russian Sputnik successes, United States attempted their first full-scale Vanguard launching on December 6. The experiment took place at the research site at Cape Canaveral, and was attended by considerable publicity. After days of delay due to minor defects, the launching was scheduled for 11.45 a.m. Unfortunately it ended in complete failure; the rocket carrying the 6-inch satellite blew up almost immediately, and exploded. Fortunately there were no casualties.

The Secretary of Defense, Mr. McElroy, described the failure as "disappointing, but not too surprising." It seems that the cause of the trouble was loss of chamber pressure in the first stage of the launching vehicle. Further attempts will be made as soon as possible.

B.I.S. Students Meeting

Each year it has become the fashion for the British Interplanetary Society to hold a meeting for the benefits of students. This year, on December 28, 1957, the Tudor Room at Caxton Hall was crowded; the younger age group was well represented, and the questions asked by the "under-fifteens" showed that they were remarkably well-informed on astronautical and astronomical matters.

The first speaker was Dr. N. H. Langton, who gave a general description of the problem of astronautics, and managed to make a complicated subject very lucid without in any way falling into the trap of making a Moon voyage sound easy to accomplish. He was followed by G. V. E. Thompson, who dealt with the great topic of the moment—satellites. After a résumé of the history of satellite research, the speaker described the principles of launching, and went on to discuss the movements of an orbital vehicle. He then turned to the Russian Sputniks, and gave the latest available information about them.

The final speaker was Patrick Moore, whose subject was "Conditions in space and on the Moon and planets." Illustrating his talk with slides, he outlined the main difficulties which future pioneers will have to face, and then described the probable conditions on the surfaces of the three nearest worlds, the Moon, Mars and Venus. Though none of these worlds can be regarded as welcoming, Moore was of the opinion that a race of men capable of crossing space from Earth to Mars would certainly be able to maintain themselves on Mars when they got there.

The meeting was then thrown open to questions, and some lively discussions ensued. It is hoped that the afternoon aroused some lasting interest among a number of those present in the audience; certainly, the younger members took their departure with every outward sign of having learned something worth-while.

The Barcelona Congress

By A. E. SLATER

Mr. A. G. Haley

Attending a scientific congress is like going to college: lectures all morning, lectures all afternoon, and go through your notes in the evening. But even students relax sometimes, and, of course, in Spain there is always the *siesta*. This account of the congress will concentrate on its more relaxing features, in contrast to the business and technical side, though it was unfortunate that, having arrived in a state suspiciously resembling Asian 'flu, one had to overdo the relaxing at first and miss the earlier social functions.

Two years before, at Copenhagen, we had all been electrified at the start of the congress by President Eisenhower's announcement of the American intention to launch a satellite. A similar electrification, at even higher voltage, took place this time with the launching of the Russian satellite a day before the Congress began. One even found oneself using it as a clock; for instance, the level of efficiency at Barcelona airport was such that between the time we landed and the time they managed to set us down in the middle of the city, the satellite made one complete circuit of the Earth.

The only other congressman among my fellow-passengers was Kurt Stehling, from the U.S.A.; most of the delegates seemed to have already arrived, comfortably in daylight. There were 170 of them on the printed list, including 38 each from Spain and the U.S.A., 20 from Great Britain—a most satisfactory figure. Thereafter came Poland with 18, Germany 17, Italy 8, France and Austria 6 each, Sweden 5, Switzerland and the U.S.S.R. 4 each, Holland and Yugoslavia 2 each, and then one each from Canada, South Africa, Argentina, Belgium, Brazil and Denmark. Further arrivals, too late to get on the list, are believed to have brought the total to over 250.

The British party included, rather unexpectedly, such people as Stewart Scott-Hall, scientific adviser to the Air Ministry; Flt.-Lieut. Victor C. Appleton, also from the Air Ministry; Albert W. Lines, of the Guided Weapons Department, Royal Aeronautical Establishment, Farnborough; and Richard W. Walker, technical director of the Gloster Aircraft Company, all of whom had been sent by their respective institutions. William H. Stephens, deputy director of R.A.E., was booked but did not appear. All this was a welcome sign of enterprise and foresight in high quarters. Among B.I.S. members were Arthur Clarke, A. V. Cleaver, L. J. Carter, Kenneth and Mrs. Gatland, Dr. and Mrs. Shepherd, A. M. and Mrs. Kunesch, and Leonard Strickson.

No time was lost in putting the I.A.F. Council and Officers to work on Sunday morning, October 6. Their sessions, as well as the technical lectures, were held in a many-storied university-like building, the Consejo Superior de Investigaciones Cientificas, in which, in spite of its name, I could find nothing resembling a research laboratory. It was, of course, hardly as grand as the Exhibition Palace where the Rome Congress was held last year, but the same is true of all earlier congresses. This meant that most of the *siesta* period was taken up in going out to get lunch, instead of having lunch on the premises and then milling around among one's fellow-delegates.

However, as none of the technical sessions ever started on time, there was usually half-an-hour for a preliminary chat and exchange of ideas among the waiting audience. There was also an extensive circulating area, though with few chairs, on the first floor landing, on to which opened the council hall and the efficient and courteous secretariat's department. On

this first day their courtesy stood up splendidly to assault by a seething polyglot crowd of newly arrived delegates, each of whom had to be relieved of his congress fee before being allowed to seize his coveted bundle of preprints.

That evening came the first social affair, a reception by the Spanish Astronautical Society, at a magnificent establishment called the Rotunda, at least five underground stations away to the north—for Barcelona is no mean city, with well over a million and a quarter inhabitants. By all accounts the reception was thoroughly stimulating. But I spent the evening in bed, sorting out preprints.

Monday afternoon saw the beginning of the technical sessions, but the I.A.F. Council and its committees were kept busy all day, and for much of the next two days as well, so they had to miss a large proportion of the technical papers. This was a pity because many of them could have contributed usefully to the discussions; in fact, Andrew Haley even had to get someone to read his paper for him because he was hopelessly busy.

But you can't have it both ways. At all previous congresses, those who came only to hear the papers had to kick their heels for a couple of days while the business sessions went on and on. The result was, in Rome, that when the technical sessions at last got going, over 40 papers could only be allowed 15 minutes each, whereas this time each of the 44 papers could be allotted half an hour. According to the programme, council and committee meetings took up 14 hours altogether, technical sessions 21½ hours, and a film show 1½ hours—total, 37 hours. Allowing for the usual all-day excursion in mid-week, it might still be possible to fit in everything without overlap—at least in more northerly, non-*siesta* latitudes.

The lecture room was no amphitheatre, but narrow with a flat floor, furnished with only 96 seats. So it was cosy—sometimes too cosy, when it had to be darkened by blinds which cut off the ventilation. But it was rarely overcrowded.

The first British contribution, by Wilfred Neat, chief engineer of De Havilland's Rocket Division, came in this first session. In his absence, Val Cleaver, his former chief, read his paper, which was about the difficulties of designing a rocket motor with variable thrust. It went down well with the experts, and must have filled the traditional "long-felt want", for I don't remember hearing this particular aspect of rocketry discussed before at an I.A.F. Congress. After all, you will need variable thrust one day for making a gentle three-point landing on the Moon, even if its present uses are for a less peaceful purpose.

After an hour's business on Tuesday morning, everyone adjourned to Barcelona Town Hall for the Official Opening of the Congress, two days after it had begun. You never know when to expect an official opening in Spain; five years earlier, at the World Gliding Championships near Madrid, the official opening came three days before competition flying actually started. The I.A.F. opening was followed immediately by a press conference, at which, of course, the entire Press gathered round the Russians in a vain attempt to pump information out of them about their satellite. Faced with this formidable opposition, our own Press officer, Kenneth Gatland, had a hard job to get any of the Press to take an interest in the British party.

Left to Right: J. Stemmer, Sec. I.A.F., Prof. L. Sedov (U.S.S.R.) Vice Pres. I.A.F., J. Marial (Spain), L. R. Shepherd (U.K.), F. C. Durant (U.S.) Vice Pres. I.A.F.

Actually the only reliable news about the satellite came from foreign newspapers imported into Barcelona, and the Russians appeared to read them as avidly as everyone else. Practically all the London dailies could be bought, about three days late, and even the air editions of *The Times* and *Telegraph*, printed on thin paper, arrived no sooner.

On Wednesday the blackboard problem arose. I needed one for my lecture at 11.30, and had twice been promised one; but it was still not there. Of course, it is against all local custom to start getting anything ready before the moment it is needed; in fact, not until the first lecture had actually started on Monday did the projectionist begin finding out whether his projector would work. Dr. Klemperer told me that he, too, had been promised a blackboard; but, when the time came, he was faced with the alternative of either going to look for it or reading his paper. So I set out to search the building, but in vain until, by concealing from the hall porter the fact that the blackboard was not wanted till two hours later, I induced him to tell me where it was and help to carry it in.

Thereafter that blackboard was used by practically every lecturer. Moreover, the press photographers, who increased in number every day, soon saw that it made an ideal background for a portrait of each lecturer. They would sit tight until he moved across to it, and then make a concerted rush to the spot and squat round in a semicircle, waiting for the lecturer to draw something.

That evening there was an excursion to a folk-lore festival in the hills outside the city, in a replica of an old Spanish village, specially built for such shows.

Thursday, however, was the big day off, with an excursion to Montserrat, the holy place up in the mountains. The scenery was magnificent, the lunch superb, and the singing by the boys' choir in the chapel is reputed to be the finest in the world. But some of us, including the Russians, were tempted up to the mountain top by a cable railway, only to find that it ran every half-hour and we could not return in time for the singing.

After Friday's technical sessions came a film show, mostly about rocketry, but including Walt Disney's new film and one showing the launching operations and final landing of Major David Simons' huge polythene balloon, hanging from which, in a sealed cylindrical "gondola", he was taken up above 100,000 feet and kept there for more than a day. More exciting still were the photographs and films taken by Major Simons from inside his gondola. He told us all about it instead of reading his paper, which had been written before he went up. Actually he sank during the night to a mere 70,000 feet, for the odd reason that there was a storm area down below which cut off the Earth's radiation coming up from the ground, so that the balloon cooled down more than it should have done. But next morning's sun sent it up again to its ceiling.

This storm area caused Major Simons to delay his descent; but he was moving from east to west in the stratosphere while the storm moved from west to east in the troposphere, so he waited for it to blow past, and for himself to be blown past it, rather than make a landing in the middle of it. His tight-fitting "capsule", to judge by the photograph, looked a lot worse than a sardine tin, but he said he had room in it to stretch his legs. What really was uncomfortable was having to wear a pressure suit, even though it was kept deflated.

Right to Left: Mrs. L. Shepherd, Mrs. Hjertstrand (background) K. Gatland, Mrs. Gatland

The B.I.S. Informal Dinner at the Barcelona Congress. Left to Right: General Barclay, Mrs. Shepherd, Dr. Simons, A. V. Cleaver, G. Sutton

Photo by L. S. Strickson

ready for re-inflation in a few seconds in an emergency. As for cosmic radiation, he had suffered no ill-effects in the seven weeks since the ascent, but if he was going to develop any grey hairs, like the mice he sent up to the same height a few years earlier, they had not yet had time to grow out through his skin.

After the film show the B.I.S. gave a private dinner to a large but selected party of some of the leading personalities present at the Congress.

On Saturday morning came the final technical session. It was notable particularly for a talk by Mrs. Alla Masevich, from Russia, who had organized 68 semi-amateur satellite-watching stations all over the Soviet Union, all during the past six months. They had a practice "alert" on September 24; and on the night of October 1, three days before the satellite went up, a jet aeroplane flew over Moscow showing a small light no brighter than the satellite would look, and crossing the sky at the same apparent speed.

Mrs. Masevich showed us a small, fat telescope especially designed for satellite-watching, with a magnification of 6 and a field of view 11 degrees across; seventeen of them had been made at an optical works near Moscow, where the workers got so keen that they organized a watching group of their own. Then, suddenly, she announced that the Russians wished to present this telescope to the Spanish Astronautical Society to watch the satellite with. This took everybody off guard, and there were frantic calls for Señor Marial, the president; but, although the whole building was searched, he was nowhere to be found. However, a deputy was produced and pushed up on to the platform, looking rather sheepish and bewildered, but he soon grasped the situation and graciously accepted the gift on behalf of his society.

Finally came the farewell dinner on Saturday night, in the big hall at the Rotunda, with a band up in the gallery gaining much applause for an international programme by Grieg, Rimsky-Korsakov, De Falla and others, and then, after the tables were cleared and pushed aside, providing dance music. Our own Leonard Strickson, who is organizing moon-watchers at Harrogate, was seen having an unusually long dance with Mrs. Masevich—it was rumoured he had bribed the band to prolong it!

Of course there were speeches. The outgoing I.A.F. President, Dr. Leslie Shepherd, thanked and congratulated the Spanish Astronautical Society, especially the president, Señor Julio Marial, and Colonel L. Castan of the organizing committee, for the meeting's success. Professor Sedov wanted to see the I.A.F. act as a base for further co-operation. Andy Haley, the newly elected President for the forthcoming year, called Mrs. Masevich to come forward, and Professor von Kármán presented her with a satellite-shaped hat, complete with three antennæ sticking out.

Mrs. Masevich had been the social success of the party, and indeed of the whole congress; she was in high spirits throughout, obviously enjoying every moment of it. We learned the reason when, in a speech, she declared herself "enchanted" with the courtesy and gallantry of the gentlemen of Spain. And she issued a warning, on behalf of all the ladies at the congress, that when they got home they would insist on similar treatment from their own menfolk. After hearing this, how many of us non-Spanish males felt burdened with a guilty conscience as we slunk out into the night?

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From the contents of No. 2, Vol. VIII (1957)

Straight Rocket Combustion Chambers (H.v. Zborowski); *Rockets, Missiles, Satellites* (A. J. Zaehringer); *Hydrogen Peroxyde or Nitric Acid?* (H. Schneider); *Scientific Results and Economical Effects of the Realization of Space Flight* (W. Trommsdorff); *Space Law* (A. G. Haley); *Combustion Processes in Rocket Combustion Chambers* (E. F. Büchner).

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UMSCHAU VERLAG

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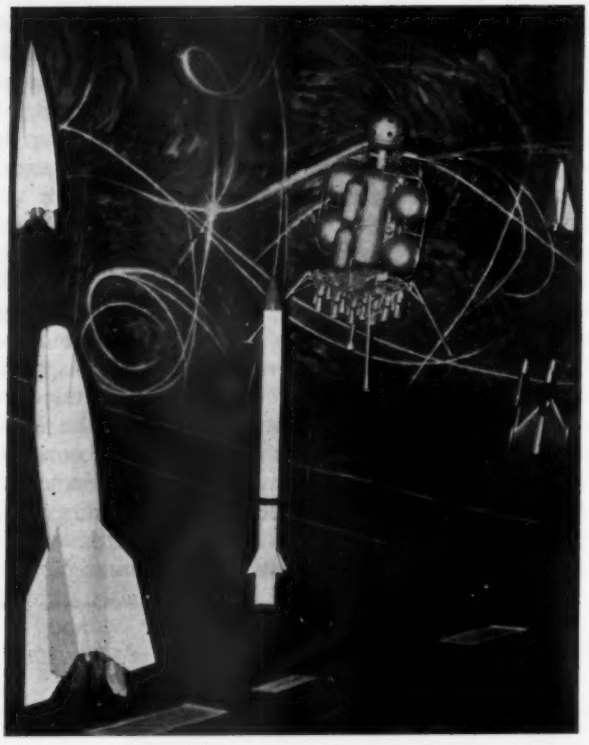
Warsaw Conference on Rocket Technique and Astronautics

By K. ZARANKIEWICZ



Astronautical Exhibition. Models of the German rockets and von Braun Moon rocket

On May 23–25, 1957, a Conference on Rocket Technique and Astronautics was held in the Palace of Culture and Science in Warsaw (Poland). It was organized by the Polish Astronautical Society. The following persons made up the presiding body of the Conference: Dr. K. Zarankiewicz, professor of Theoretical Mechanics, Warsaw Polytechnic, president of the Polish Astronautical Society; Dr. J. Bukowski, professor of Aeromechanics, Warsaw Polytechnic, member of the Seym (Polish parliament); Dr. E. Olszewski, professor of the History of Technical Sciences, Warsaw Polytechnic; Dr. Zb. Pączkowski, professor of Applied Mechanics, Warsaw Polytechnic, vice-president of the Polish Astronautical Society; Ing. D. Smoleński, professor of the Technology of Nitrogen Compounds, Rector of the Wrocław Polytechnic, member of the Seym.

On the first day of the Conference the principal papers were delivered: Professor Zb. Pączkowski—Problems of the Development of Rocket Technique; Professor Dr. K. Zarankiewicz—On the Present State of Astronautics; Professor Dr. E. Olszewski—On the Centenary of the Birth of K. Ziolkovsky. Altogether 24 papers were delivered, dealing with the following subjects: drive and driving materials (9), control and guidance (2), mechanics of flight (1), external ballistics (2), technological problems (1), astronomy and astronautics (3), physiology and biology (3).

About 180 scientific workers took part in the Conference (two guests from Czechoslovakia among them).

The object of the Conference was to review the work that had so far been done in Poland in the field of Astronautics, particular attention being paid to rocket technique.

In connection with the Conference a popular Astronautical Exhibition, prepared by Ing. W. Geisler, was opened at the Museum of Technical Sciences in the Palace of Culture and Science.

The next Conference will be held in 1959.

Presiding body of the Conference: (from left to right) F. Bukowski, F. Kliesko, K. Zarankiewicz (speaking), Z. Pączkowski, D. Smoleński

The Ramjet in Astronautics

By S. W. GREENWOOD

What is a ramjet? Has it a place in astronautics?

Atmosphere-breathing Engines and Rocket Engines

We are so accustomed to thinking of the use of rockets for travelling through the vacuum of space that we are at times inclined to neglect the fact that our own planet and many other bodies in space possess extensive atmospheres which could be used for the purposes of propulsion.

A rocket engine produces thrust by discharging material originally carried in the vehicle. An atmosphere-breathing engine produces thrust by taking in gas from the atmosphere and discharging it at a higher speed than the speed at which it was entrained. Taking a very general view of the position, it may be said that, while travelling through a reasonably dense atmosphere, an atmosphere-breathing engine will produce a given thrust for a given period of time for a smaller consumption of vehicle-transported propellant than would a rocket engine. In some missions this saving of propellent may be important. The atmosphere-breathing engine will generally be heavier than the corresponding rocket engine. The relative advantages of different engines will, of course, depend on the particular details of any given mission.

This article is intended as a brief introduction to an atmosphere-breathing engine which is becoming increasingly important, particularly as a power plant for supersonic flight, and the reader may care to ponder upon some suggestions regarding possible applications of the engine to astronautics. Here, then, is an introduction to—the ramjet.

The Principle of the Ramjet

The principle of operation of the ramjet is almost as simple as that of the rocket engine. Certainly, there is no simpler atmosphere-breathing engine. This simplicity is not, unfortunately, quite so apparent to those who have to test and develop these engines, for there are many engineering problems to be tackled and overcome with each new engine, as in the case of a new rocket engine. However, we are probably not personally involved in these trials and tribulations, and are thus permitted to view the engine in a relatively dispassionate manner.

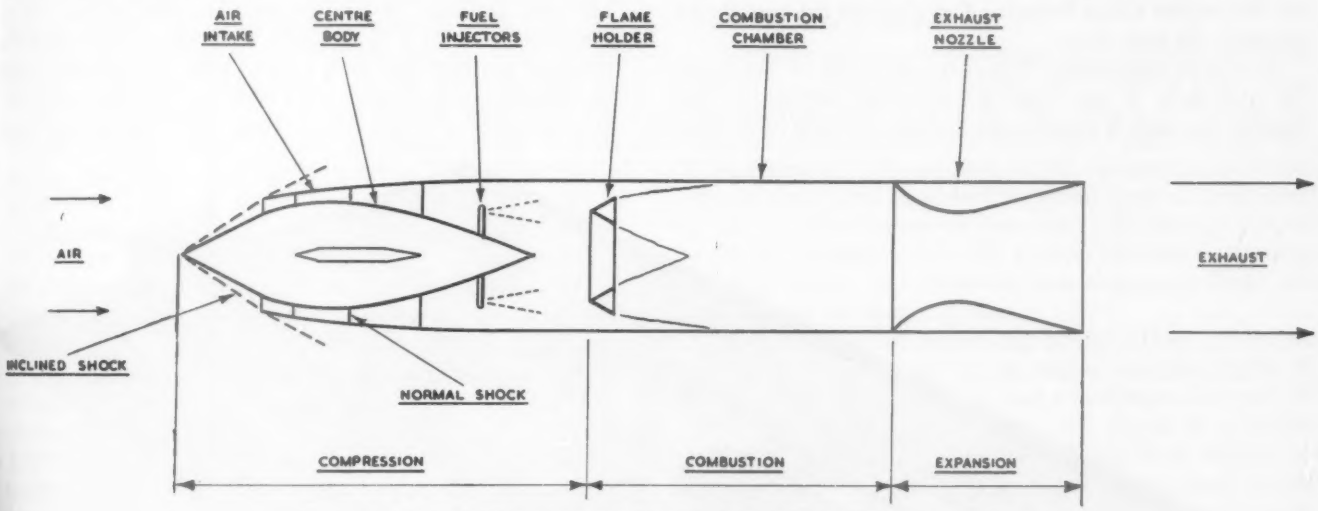
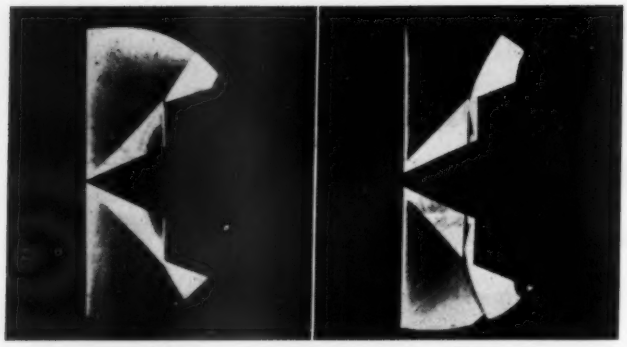


FIG. 1. Diagrammatic layout of supersonic ramjet

A typical Earth-based supersonic ramjet is shown in Figure 1. Apart from the fuel supply and control system, which are not included in the diagram, it is apparent that the engine consists simply of a duct with some internal fittings, and that there is a complete absence of moving parts.

In operation, air enters the intake and is compressed, first across inclined shock waves produced by a suitably designed centre body, then across a normal (or perpendicular) shock wave whose position inside the intake varies with the engine operating conditions, and finally by slowing down the air by progressively increasing the flow cross-sectional area. During the latter stages of compression, fuel, usually petrol or kerosine, is injected and mixed with the air. Some of this mixture of fuel and air then passes over a flame holder where it is ignited by previously burnt gases in a sheltered mixing region. Most of the remainder of the mixture then burns in the



(a) (b)

FIG. 2. Operating conditions of supersonic intake
(a) Supercritical (b) Subcritical
By courtesy of The Bristol Aeroplane Co. Ltd.

combustion chamber. The final process is the expansion of the hot gases in a suitably-shaped exhaust nozzle, resulting in a high-speed propulsion jet. In the same way that the exhaust jet produces thrust, so the entering air jet causes a drag on the engine. The resulting thrust on the engine arises from the fact that the exhaust thrust exceeds the inlet drag.

It will be appreciated that some drag will be produced by the flow of air over the external surface of the engine, but this is usually small relative to the inlet drag.

Range of Application of the Ramjet

In our consideration of the principle of operation of the engine we saw that compression of the inlet air results from the effect of the flow passages on the air. In this way some control is exercised over the manner in which the air is rammed into the engine. The higher the flight speed, the higher the pressure caused by this ram effect, and the higher the thrust and the performance of the engine. When the engine is at rest, there is no ram effect, and hence no thrust. This is probably the most serious limitation of the engine—it is useless at rest, and will produce thrust only when some other propulsion system has brought it up to speed.

The engine operates best at high speeds, and it is unfortunate that there are two factors which, in effect, tend to set an upper limit to the speed at which the engine can be operated. Both are limitations due to high temperature. The first factor is that the entry air is heated by compression, and the importance of this may be seen in Table I. At a flight speed of $\frac{3}{4}$ mile/sec. the ram temperature is 580° C., a dull red heat, and the internal surfaces of the engine become heated to a temperature only a little lower than this. The engine's external surfaces are able to lose heat by radiation and so operate rather cooler. At 1 mile/sec. the ram temperature is 1,020° C., and it is evident that further increases

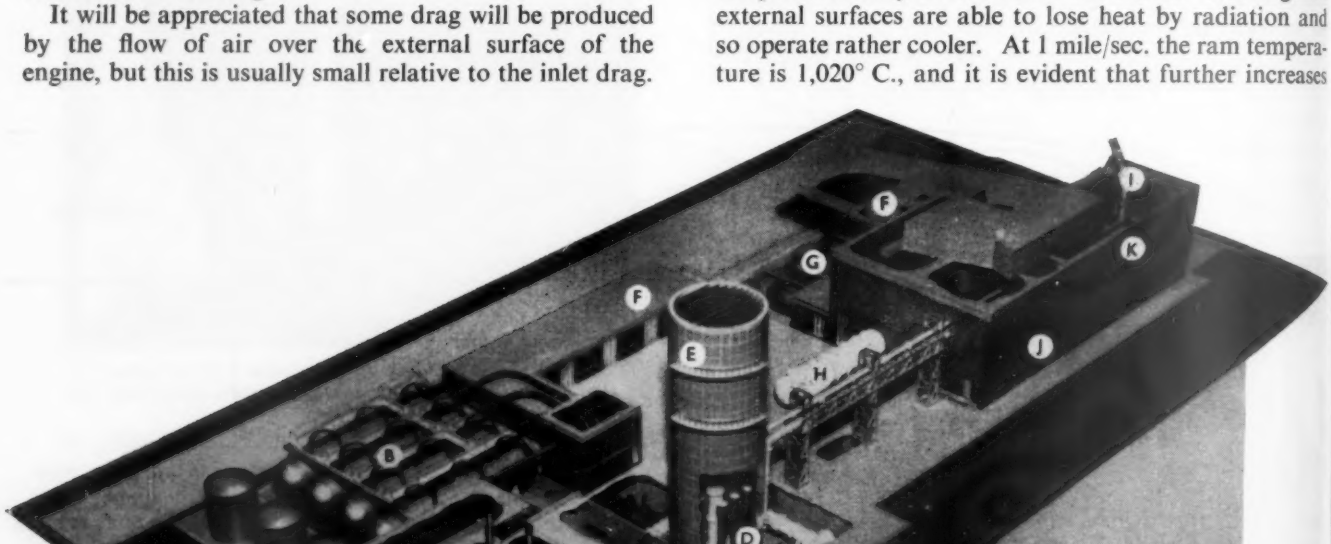

A BOILER FUEL TANKS
B STEAM ACCUMULATORS WITH WATER RESERVOIR UNDER
C STEAM BOILERS
D STEAM EJECTORS
E SILENCING TOWER
F WORKSHOPS OFFICES ETC
G TANKS FOR RAMJET FUEL
H DOWNSTREAM END OF TEST DRUM
I AIR SUPPLY 160 lb SEC AT 6:1
J CONTROL ROOM
K AIR HEATING AND COOLING ROOM

FIG. 3. Model of new Bristol test plant for testing ramjets at high altitude
By courtesy of The Bristol Aeroplane Co. Ltd.

FIG. 4. Leduc 010 on its Languedoc carrier

in speed would result in steep increases in ram temperature. The problem here is more severe than in the rocket engine, as the fuel flows available are too small to use for cooling the internal surfaces of the engine. The second factor is that the temperature of the gases leaving the combustion chamber must be higher than the ram temperature in order to produce thrust. The problem of the internal surface temperature of the engine is thus even more severe at the exhaust end. These two factors taken together tend to suggest that practical ramjets which can be considered today will not be expected to fly at speeds greater than 1 mile/sec. This looks a little disappointing when considered in the light of, for example, Earth satellite speeds of about 5 miles/sec.

The ramjet cannot be operated to as great an altitude as might be desired owing to the progressive thinning-out of the atmosphere as altitude increases. This is shown in Table II, where air pressure is given at different altitudes, together with ram pressures in a typical engine at a flight speed of $\frac{3}{4}$ mile/sec. At 120,000 ft, the ram pressure is about one-half the value of the air pressure at sea level. At such a low pressure, difficulties would be encountered in keeping the flame alight, and combustion would tend to become rather inefficient. Under these conditions the engine would be producing only a marginally useful thrust. It appears that, in its present state of development, the engine can be considered for operation only at relatively low altitudes by astronautical standards.

Of the various practical problems at present confronting the ramjet engineer, one of the most serious is that of controlling the engine behaviour in such a way that the normal shock in the intake compression system remains within the intake. This condition is called "supercritical" operation of the intake. It is general experience that if the normal shock is permitted to occur ahead of the intake, then undesirable fluctuations occur in the flow. This may result in loss of thrust and, in its severest form, in extinction of the combustion flame. It is, therefore, considered necessary to avoid this condition, known as "subcritical" operation. The two conditions referred to are made visible by special optical techniques in Fig. 2. Avoidance of "subcritical" intake operation necessitates operating the engine above a certain minimum flight speed. The engine is thus able to operate only in a certain speed range. The alternative to fixing a lower speed limit would be to introduce a means of varying the flow areas in the exhaust nozzle, but this presents obvious difficulties.

The range of operating conditions is wide enough to be a problem for the test engineer. The scale of test plant required to test an engine on the ground over a range of simulated speeds and altitudes may be judged from the model shown in Fig. 3. The engine under test is housed in the test drum shown as "H." The rest of the equipment, together with air compressor plant not shown in the photograph, exists for the purpose of determining the behaviour and performance of the engine. It is evident that the size and operating range of a proposed engine may to some extent be limited by available test plant capacity.

Some Typical Engines

Many nations are now engaged in ramjet development. Credit for the earliest ideas and most of the initial engineering goes largely to the French. The Leduc series of manned ramjet aircraft, Figs. 4 and 5, represented bold ventures. The aircraft shown operated at subsonic speeds, and were launched at speed from conventional aircraft. More recent versions take off from the ground using gas turbine power, and go over to ramjet operation when in flight. It is expected that supersonic flight will be achieved on ramjet power.

A modern British ramjet, the Bristol "Thor", is shown in Fig. 6. This is a supersonic engine, and one engine of this type, recently exhibited, had a maximum diameter of about 16 in. An engine of this size would be expected to give a sea-level thrust of about 5,000 lb. at Mach 2 or about 15,000 lb. at Mach 3. The engine thrust would fall off with height, the thrust being approximately proportional to the relative air density. The specific fuel

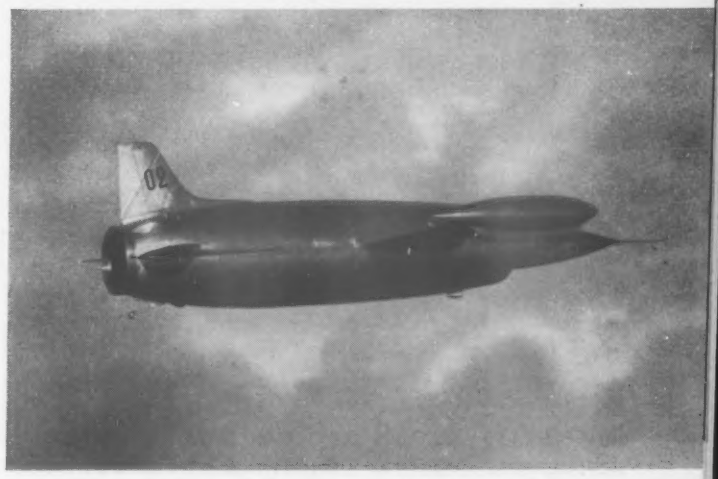


FIG. 5. Leduc 021

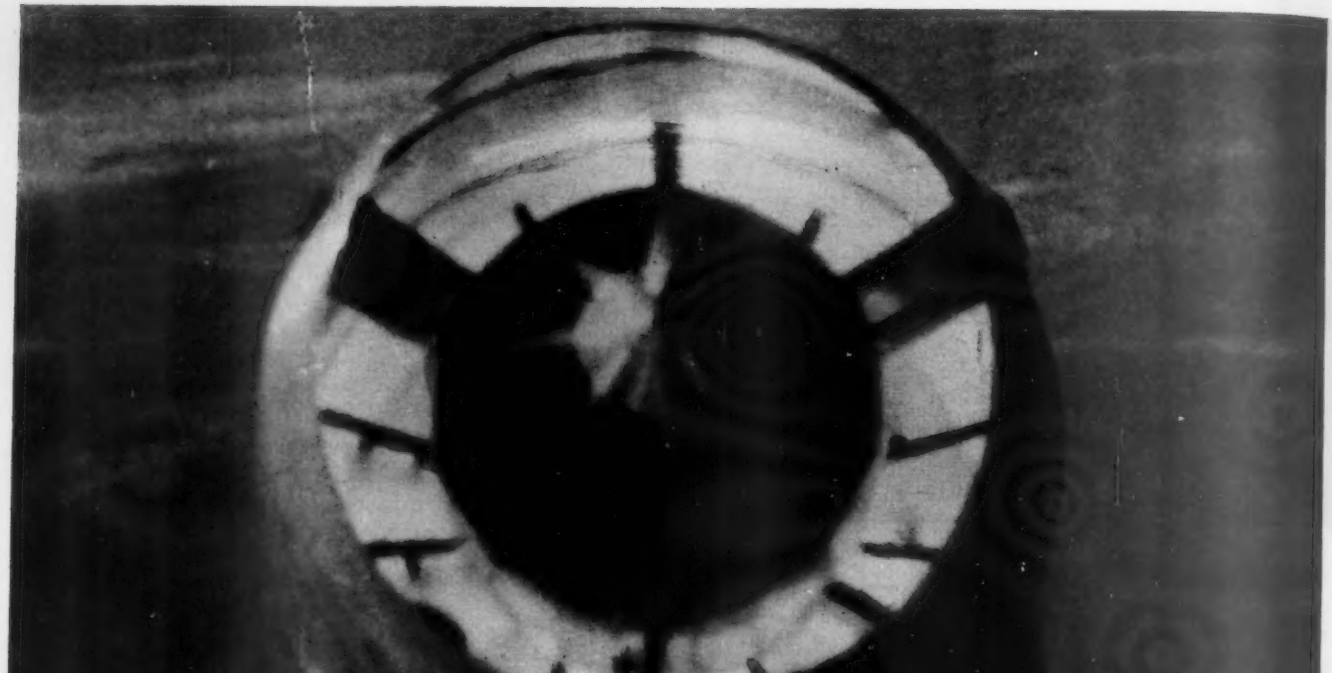


FIG. 6. The Bristol "Thor" Ramjet, taken by cine camera during free flight. The centre body and fuel jets can be clearly seen
By courtesy of The Bristol Aeroplane Co. Ltd.

consumption would be expected to be between 2 and 3 lb./hr. for each Lb. of thrust, compared with the very much poorer value of about 15 lb./hr. for a typical rocket engine. Few details are available on the Bristol engine, however, owing to security restrictions.

Fig. 7 shows the N.G.T.E.-Napier ramjet test vehicle. This photograph is of particular interest in showing the booster rocket engines used to accelerate the vehicle up to speed. It is evident that the booster may be as bulky and as heavy as the ramjet vehicle.

Possible Applications to Astronautics

The first application that comes to mind is that of a ramjet-engined second-stage in a step vehicle for establishing an Earth satellite orbit. Arthur C. Clarke uses this device in one of his earlier novels, *Prelude to Space*. His first stage is a launching system that remains on the ground, and his ramjet is nuclear powered. He visualizes that the ramjet would make a substantial contribution to orbital velocity, rocket engines being used for the final entry into orbit. No figures are quoted to give some substance to the suggested technique, but, after all, the book is not intended to be read as a design study. We have already seen that the ramjet in its present state of development tends to be limited to speeds below 1 mile/sec. and the problem of reaching orbital speeds of about 5 miles/sec. is still a big one. In the novel just referred to, the ramjet is used during the final stages of the returning glide back through the Earth's atmosphere to give the pilot control over the machine during the approach to landing.

The contributions to thrust at some stage during entry into orbit, and controlled return to Earth, are clearly desirable features for such a vehicle. The obvious snag is that beyond the denser regions of the atmosphere the engine is so much dead weight, and a penalty must be paid for carrying it around. This penalty may be alleviated to some extent by combining the structure of the engine with the structure of the vehicle, that is with the fuselage or the wing.

The use of ramjets on an aeroplane first stage has been suggested by Prof. Paul E. Sandorff, of Massachusetts Institute of Technology. The aeroplane would have mixed power plants. It would use its ramjets when up to speed in order to give the stages it launches as high an initial speed as possible. One of the advantages claimed for this technique is that it would ensure greater reliability than conventional techniques using a number of rocket stages. It would also permit recovery and re-use of the first stage.

Similar proposals have been made recently by Professor M. Varvarov of Russia. In his first proposal, a

winged vehicle with mixed power plants is employed. Turbojet power is used in the initial period of flight. Ramjets would then be operated and the turbojets jettisoned. Later, the ramjets would also be jettisoned and the mission completed on rocket power. In his second proposal, a winged turbojet vehicle launches a winged ramjet vehicle that in turn launches a rocket vehicle.

So much for flight in the Earth's atmosphere. The atmospheres of other bodies in space may be suitable for propulsion purposes, and it is desirable to consider whether we might be able to use them during flight through these atmospheres instead of having to haul rocket propellants over long distances. If we are confined to chemical combustion, it seems that only a few bodies in the Solar System would be suitable for ramjet propulsion. The atmospheres of the "giant" planets, for example, may consist to a large extent of hydrogen and methane, and it might be possible to burn injected oxygen or oxidants in these atmospheres. Unfortunately the ratio of injected oxygen to the flow of atmospheric hydrogen would be relatively high, and the specific "fuel" consumption of such an engine does not appear promising. One way around these problems is, of course, to develop a power source of the nuclear type, in which a system carried by the vehicle releases heat with the consumption of only a small amount of material, the atmosphere passing through the ramjet duct then being heated by heat transferred from this system. The chemical composition of a particular atmosphere would then be less likely to affect the operation of the engine.

One application that comes to mind is that of exploring the surfaces of some bodies having atmospheres by means of a helicopter with rotor-tip ramjet drives. With such a machine one could make a useful preliminary survey of the surface conditions before touching down with a larger machine. The problem of releasing and retrieving the exploration helicopter is likely to be considerable, but so are all the problems of astronautics.

Has the Ramjet a place in Astronautics?

This is a tricky question, as are all questions involving prediction.

The author's present optimism regarding the place of the ramjet in astronautics is based on the following reasoning: The present limitations of the engine arise partly from the late start in the development race compared with the rocket engine, due to the need for complicated plant for ground-testing ramjet engines over a sufficiently wide range of simulated flight speeds and altitudes. In the past few years such plants have been coming into operation, and one may expect an increased rate of development as a result.

The acute problem of dealing with the high temperatures encountered at high flight speeds in the atmosphere, for so long avoided in rocketry by travelling for very short periods under these conditions, is now receiving

[*Continued on p. 219.*

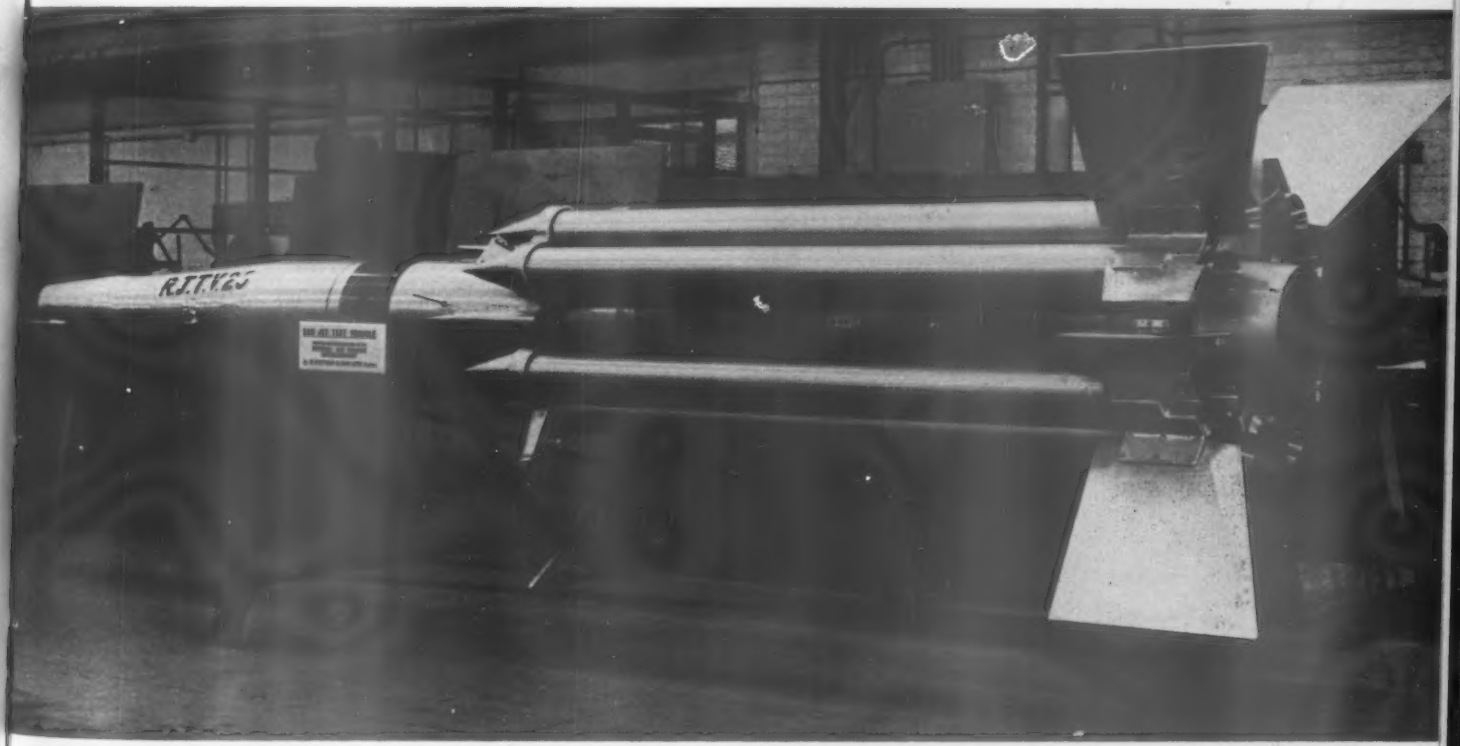


FIG. 7. N.G.T.E.—Napier test vehicle complete with eight solid propellant rocket boost motors. The large stabilizing fins provide additional stability at launch. Mid-way along the fuselage are the ram air intakes and exhaust duct for the turbine-driven fuel pump
By courtesy of D. Napier and Son Ltd.

Conditions on the Moon with which the First Landing Crew will Contend

By GILBERT FIELDER, B.SC., PH.D., F.R.A.S.

One day before the end of this century, men, it seems, will be ready to land upon the frightening surface of the Moon. They will have had close-up views of it before this time, and seen the chaos and variety in the blocks of rock which at one time must have tumbled down from the tops of the jagged mountains. They will have chosen the part of the lunar surface which must act as their landing stage, and the feet of their rockets will have been specially designed to cope with the nature of the ground at this locality.

How much of what these men will know at that time can we predict now? What do we know already about the detailed structure of the Moon's surface?

The Moon is a dead body, but it receives radiation from the Sun and reflects or re-emits this radiation after altering it in some special way which is characteristic of its surface. If we analyze this radiation we may learn many things about the surface, and even about the inside, of our satellite.

The Full Moon

Consider the properties of light, first of all. We know the intensity of the sunlight which falls upon the Moon, and we can measure the Moon's brightness. From these things, it is possible to estimate how much light the Moon reflects, and it turns out to be a very small amount; only some 7 per cent. This means that the surface must be, on the average, fairly dark. Certain parts, such as the dark patches which are called "maria", reflect much less strongly than the "continental" regions, and this can be verified by any keen-sighted person, at time of full Moon, even without a telescope.

With optical aid, it is possible to measure the shadows, usually appearing jet black by contrast with the brightly-lit surrounds, which are cast by the innumerable mountain peaks, and so, knowing the angle which the Sun makes with the level terrains on which these peaks stand, one can estimate their relative heights. The lunar Apennines have peaks which reach 20,000 feet above their bases, and the ringwalls of many craters rise to more than half this height above their sunken interiors.

Although the larger craters without central mountains usually have slightly convex bottoms, the general appearance of such a crater to our space-crew will be that it has a flat floor. But the men will see also an infinite variety of hills and small valleys, swellings and depressions, differences of sizes and colour of rock-blocks.

Some of these things can be seen telescopically when the sun is just rising or setting over a crater: at these times minor irregularities are given away by the long shadows which they cast. Thus, the seemingly flat-bottomed crater Ptolemæus, some 95 miles from edge to edge, has its floor smeared with many saucer-shaped depressions, low ridges, mounds, and scores of minute crater pits closely packed, yet each only a mile or so in diameter: the complexity of the inside of this crater will be almost inconceivable when first seen clearly.

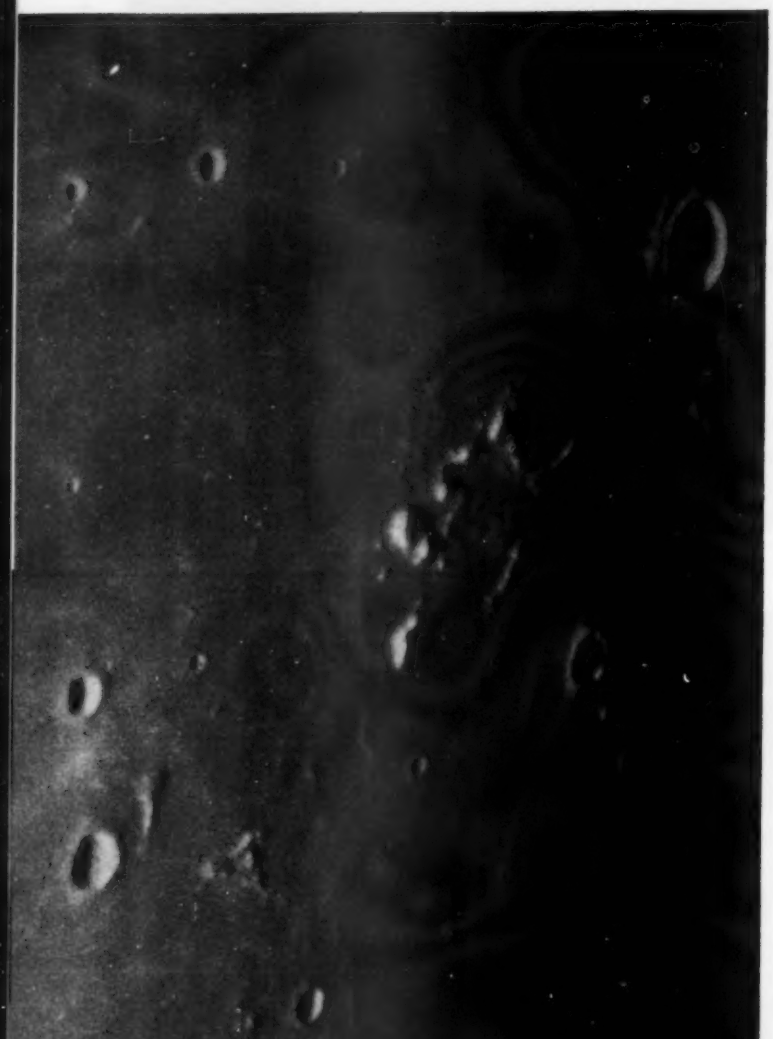
Other important properties which moonlight has are colour and polarization. We already know that maria appear to be darker to the eye than the mountainous regions. Are these features of different colours or of different materials? The answer is "Yes" in both cases. Often, maria reflect less red light than do the mountains. It is not easy to detect colour differences with the naked eye, but instrumental work has shown that the colour of the Moon's surface varies from place to place. Mare Tranquillitatis, for instance, is greener than Mare Serenitatis (except round the edges of the latter) and there is a patch near to the crater Aristarchus, called Wood's Spot, after the discoverer, which is dark in

Region of Pitatus. 1956. Dec. 11

Region of Arzachel, Thebit, Walter. 1956. Dec. 10

[*Photos by G. Fielder, Pic du Midi*]

ultra-violet light and bright in yellow light. Rocks containing sulphur appear to behave in much the same way as Wood's Spot, and the inference to be drawn from this is that there may be some sulphur on the Moon. Many other interesting things have been found out by studying the colours of the lunar rocks; a small iron content is indicated, for instance, and, indeed, there is nothing surprising about this, since a great amount of fragmental iron must have arrived in the bodies of meteorites.



Region of the Harbinger Mountains. 1956. June 19-20
[*Photo by G. Fielder, Pic du Midi*]

Next, we know that maria polarize light about twice as strongly as the lunar continents when the polarization is a maximum, at about the First and Last Quarters, and that comparison of the polarization-phase records with similar records for laboratory specimens indicates that the Moon polarizes as if it had a covering of some sort of dust such as volcanic ash.

All these things can be deduced from analysis of the light which the Moon sends us, but there are other kinds of electromagnetic radiation which it transmits to us as well.

By a difficult procedure, in which very sensitive receiving instruments are employed in conjunction with large telescopes, the temperature of the lunar surface can be estimated. When the Sun is vertically above any point near to the Moon's equator, the temperature of the surface rocks probably surpasses 130° C., and at night-time the temperature drops rather abruptly to minus 150° C. This great range of surface temperatures, together with the characteristic manner in which the temperatures vary, is consistent with the theoretical deduction that the Moon can have next to no atmosphere. Also, the Moon's surface must be a very poor conductor of heat.

These things have been known for a long time: a more recent discovery is that the Moon emits radio waves. The Moon itself does not provide the energy for producing these emissions, however; the energy comes from the Sun in a different form, and is modified by the Moon in some special way which is dependent on the physical properties of the lunar rocks. Records of these radio emissions confirm the thermal measurements, in that the surface rocks must be bad heat conductors.

Let us see now how all these properties are going to affect our lunar landing. Suppose that we were to pick out an apparently flat area in Mare Tranquillitatis, looking at it from the distance of one of the Earth's space stations, and send our men off to land there. Once the landing trajectory had been calculated, it would not be easy to change it in mid-stream. What would happen if a ship was going to sit right on the top of a low dome, some five or ten miles in diameter? These swellings are well known, and they are difficult to detect because they are extremely low and do not cast prominent shadows. Their origin is unknown but it is not beyond possibility that beneath them gaping cavities are concealed. Neither do we know how rigid these domical caps might be.

Or, again, suppose that the rocket ship were going to set down in such a manner that only one of its legs would hit a hill of rock even a few feet high, or such that one leg would fall into a deep cleft some 20 feet across—a cleft which, nevertheless, had not been detected beforehand. It is obvious that to attempt a landing without first scrutinizing most thoroughly the proposed landing region would be lunacy. Very many close-up photographs of a selected region would have to be taken and fashioned into a mosaic for careful study and checking. The flattest part, once selected, would then have to act as the landing stage of a specially designed

unmanned rocket, equipped in all probability with a framework of horizontal girders, each many yards long, forming the landing feet. Provided a region composed of fairly uniform irregularities could be found, the longer these girders were the less chance would there be of the rocket's toppling over by more than a few degrees from the vertical. It seems that the three shock-absorbing legs which have been suggested in the past would be out of the question. Shock absorbers could still be provided with the girder system suggested, of course, and, in fact, the landing vehicle would be more legs than body! After several successful unmanned landings had been made, the stage would be set for our Moon Men.

Wearing durable space suits, pressurized, with an interior atmosphere which would have to be mechanically maintained, and well insulated against the heat and cold and even against the possible action of micro-meteorites (counts of meteorites would have been made previously) the first jobs of these men would be extremely hazardous. Living most of the time in their landing craft, they would have to prepare a fairly level area so that another rocket might be able to land and take them off the Moon.

Who knows what dangers and difficulties they might experience on stepping out of their craft with stacks of explosives and trailing fuses? Working in the daytime they would have to look through dark filters, to keep out the intense, ultra-violet waves which would otherwise blind them. At night, they might work in the earthlight, or with powerful torches, slowly and cautiously emerging from their ship, diverging across the weird lunar wastes, laying their charges, and slowly retracing their steps. This seems to be a slow, almost impossible way of preparing a safe landing stage, but somehow or other the difficulties will have to be overcome.

Already, we have assumed a great deal. What if the surface turns out to be unstable, deep in dust or riddled with potholes? These things we have yet to discover, and when our men do eventually straddle in their space suits across the perilous, uneven surface, passing the giant rock boulders, frightening in their unstable poise, and each casting long, pointed shadows across dust and breccia of unknown composition, they will look back at the great dangers which have been overcome, and they will look ahead and see and feel for the first time the dangers which lie before them.

"I said, you must get a lot of rain where you come from!"
With acknowledgments

Continued from p. 215]

considerable attention as a result of the need for solving the I.C.B.M. re-entry problem. The new knowledge of materials behaviour and heat transfer at high speeds gained in these and other researches should contribute to raising the upper speed limits of ramjet vehicles. The greater the speed range over which operation is possible, the greater the advantage of the relatively low propellant consumption of the ramjet.

But the greatest advantages may be expected from the nuclear ramjet if it can ever be developed to a practicable stage. Such an engine would consume only a small amount of material—the nuclear material converted to energy. In contrast, the nuclear rocket engine must discharge inert material initially carried by the vehicle, in addition to consuming nuclear material.

The true relative picture will eventually emerge with the continued energetic tackling of propulsion problems. The rapid progress in rocketry during the past few decades has been aided by an enthusiasm for astronautics on the part of many rocket engineers. A similar enthusiasm may in due course prove a valuable stimulus in helping achieve the necessary progress in fields hitherto regarded as essentially aeronautical.

The author is grateful to the following who assisted in the supply of illustrations for this article: Mr. M. A. Nedham and Mr. D. G. Jenkins of Bristol Aero-Engines Ltd., for Figs. 2, 3 *and* 6. *Mr. Leonard Bridgman for Figs.* 4 *and* 5. *Mr. K. M. Hendley, of D. Napier & Son Ltd., for Fig.* 7.

TABLE I

Ram Temperatu e in Stratosphere of Earth

Flight speed, mile/sec.	Flight Mach No.	Ram Temperature, °C.
0	0	− 60
¼	1·33	20
½	2·65	240
¾	3·98	580
1	5·30	1,020

TABLE II

Ram Pressurcs in Typical Engine at Flight Speed of ¾ mile/sec. in Earth's Atmcsphere

Altitude		Air Pressure	Ram Pressure
Ft.	Miles	Lb./sq. in.	Lb./sq. in.
60,000	11·35	1·05	105
80,000	15·13	0·40	40
100,000	18·93	0·15	15
120,000	22·75	0·07	7

Radioactive Recovery Technique for Missiles and Aircraft

By FRANK POLLARD

The problem of locating and recovering missiles or rocket test vehicles has necessitated extensive ground search, and in a great many cases the loss of valuable test data and equipment when the vehicle cannot be found. Normally air and ground parties in light aircraft, jeeps or trucks will visually comb an area where a test vehicle has impacted, in hopes of recovering this valuable equipment. This process in many cases is a long operation and a great percentage of the time could be cut to a minimum by the use of new techniques. Recently, the use of radioactive isotopes or sources has been found to be an effective method of locating missiles in a very short time after impact. This radioactive recovery technique insures the recovery of test vehicles after experimental flight test. The detection, storage and handling equipment necessary in this technique is relatively simple and inexpensive, although trained personnel are required to handle the intense radioactive sources used.

In a typical test operation, ten minutes before the launching of a rocket or missile, the radioactive source is removed from its protective lead shield. This source is contained in an Allen screw approximately 1 inch long, $\frac{3}{8}$ inch outside diameter and weighs 1 or 2 ounces. Using a 6 feet long aluminium rod fitted with a magnetized Allen wrench at one end, the radioactive source is placed in the test vehicle.

At the end of the flight test the exact impact point of the test vehicle is seldom observed visually or with radar. However, under normal experimental firing conditions the impact point is usually known to be within a square area approximately 10 miles on a side. Using airborne scintillometers carried in light aircraft or helicopters, the impact area is searched by flying parallel grid lines about 3,000 feet apart until the scintillometer detects the radioactive source contained within the test vehicle.

It normally requires 3 hours to search a 10 mile square area completely, flying this type search pattern. However, in 40 experimental flight tests where this technique was used the recovery time averaged 30 minutes. Once located and marked with flares, the radioactive recovery crew transports a trailer containing the protective lead shield to the impact site. The source is then removed, again using the 6 feet long aluminium rod, and placed in the protective container. The mechanics of removing the radioactive source from its lead shield and placing it in the test vehicle takes from 30 seconds to 1 minute. The time necessary to remove the source from the recovered vehicle is the same. Under normal operating conditions the recovery crew will receive only negligible and often unmeasurable amounts of radiation.

Two types of radioactive source or isotope have been used with this technique. Research into other sources is under way. The original source used consisted of 2 curies of cobalt 60. Cobalt 60 has a half-life of 5·2 years and an effective lifetime of 20 years. A new source has recently been introduced—4 curies of antimony 124. Antimony 124 has a half-life of 60 days and an effective lifetime of 8 months. This change in radioactive sources was introduced to reduce the hazard involved in the event of an experimental flight test vehicle which impacted in a stable condition, buried itself and was never found.

This technique has been used successfully in over 40 flight tests to date. The technique has been extremely successful and the test vehicles have been located in a matter of minutes after impact. Several of these vehicles broke up in flight, but in every case the radioactive source and the instrument package was located. In no case during any of the tests using this technique did any individuals in the recovery crew receive more than the daily allowable dose of radiation and in most cases the radiation was low enough to be negligible.

The intensity of the radioactive source is not affected by high shock forces or the high accelerations encountered in flight. The weight of the source has little or no effect on the performance of vehicle and its size is such that it takes very little space in a crowded equipment or instrument section. The source itself will not affect electronic equipment and for short periods has no effect on ordinary photographic film. It is possible to place the source in a vehicle at a distance from cameras where even special photographic film will not be affected.

There are many applications for this technique. With missiles, rockets and components a radioactive source may be placed in instrumented sections where recovery of recorded data is necessary and speed of recovery essential. It may also be used to recover camera pods, instrument package, propulsion units and materials specimens which are ejected from test vehicles during upper atmosphere studies.

Millicurie sources (1 millicurie equals 1/1,000 of a curie) are available for use in experimental aircraft flight test. Using millicurie sources, individual components within an airplane can be tagged and in the event of pilot bail-out or a destroyed aircraft, these valuable components can easily be located in the wreckage using

scintillometers. These small sources will require little or no shielding to protect aircraft operating personnel.

Recovery of bomb casings after experimental drop tests can also be accomplished by this method. These casings may contain equipment and instruments which must be recovered. In the case of bombs that will "dig in" and are not easily located without extensive earth moving, two modifications of the radioactive recovery system can be employed to make it effective: (1) if the bomb digs in, the attenuation effect of the ground can be accommodated for by using a more intense source, and (2) an isotope which emits high energy gamma rays can be used.

This radioactive recovery technique is only one of a number of new applications of atomic energy to the field of missiles and rockets.

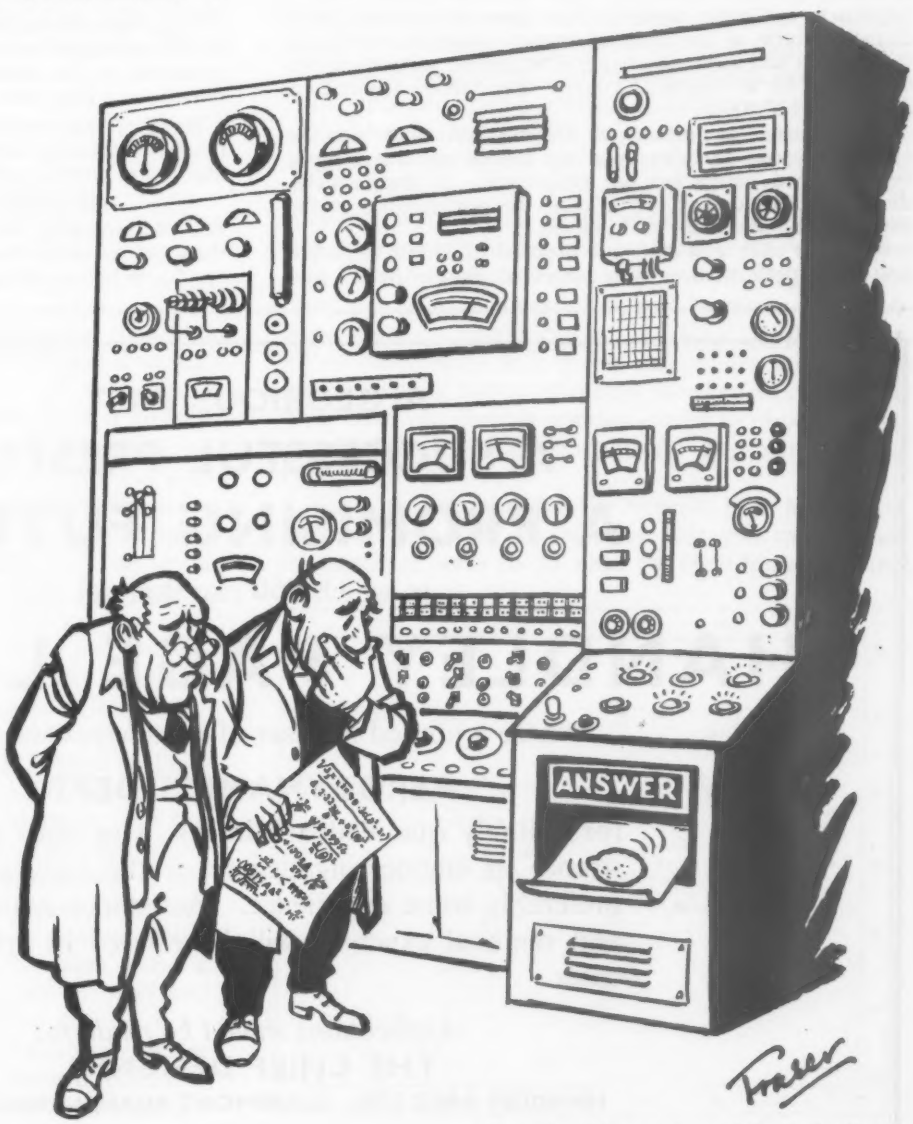
Astronautics in Burma

On August 22, 1957, a lecture on Interplanetary Travel was delivered to the Burma Council of World Affairs by Mr. F. A. Warner, member of the British Interplanetary Society. It is believed that this is the first public lecture on the subject which has ever been given in the Union of Burma.

By courtesy of the British Council, the meeting was held in the British Council Lecture Room in Phayre Street. About eighty persons attended including the Hon'ble U Raschid (in the Chair), Minister for Mines, U Ohn, Adviser to the Prime Minister, Dr. F. Ba Hli, Director of the Union of Burma Applied Research Institute Brigadier Kyaw Win of the War Office and Mr. J. S. Furnivall, Economic Adviser to the Burma Government. The remainder of the audience was largely drawn from the University and technical institutes. There were also two pongyis (Buddhist monks) in their yellow robes, whose search for "other worlds" is normally of rather a different kind than that of astronauts. In their gaily coloured longyis (sarongs) the audience made a more pleasing impression than the rather drably garbed scientists at meetings in the West.

As the Hon'ble U Raschid said in his introductory remarks, the problems of interplanetary travel are familiar to few people in Burma. There is no aviation industry in the country or highly developed chemical or engineering industries such as are necessary for any participation in rocket programmes. Burma still has to cope with the simpler problems of building up a modern economy. On the other hand, the great majority of undergraduates at Rangoon University are studying science courses and every year scores of them are sent abroad on study scholarships to Britain, Amercia and other countries to take advanced scientific courses. Amongst them there will be many who are likely to take a lively interest in interplanetary problems and Mr. Warner is trying to encourage a group to enter into correspondence with the British Interplanetary Society and keep in touch with developments so that one day Burma will be able to make her contribution to the subject.

Meanwhile, the matter remains of absorbing interest to the Burmese public who, like many European peoples, have their own legends of men who have flown to other worlds on the backs of fabulous beasts.



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Balloon Ascent by Mammals

Much apprehension connected with the exposure of crews in high-flying aircraft to primary cosmic radiation in the stratosphere is being eliminated by A.R.D.C. research projects conducted in the Space Biology Branch of the Aero Medical Field Laboratory at Holloman Air Development Centre, New Mexico.

Serious questions had arisen concerning the effects of these cosmic particles upon the human body, for it had been pointed out that the penetration of these particles into the body of a traveller in the stratosphere might cause formation of cataracts of the eye lens, damage the skin or permanently destroy nerve cells which cannot be replaced in the body.

It was decided that huge plastic balloons might prove practical for such experiments to find out whether these hazards existed or not, since they could maintain altitudes higher than 90,000 feet for at least 28 hours—long enough to expose experimental subjects to primary cosmic radiation in the stratosphere.

These balloons were used to expose living animals to radiation during a series of flights at Sault Sainte Marie, Michigan, and facts gathered from these experiments have dispelled some of the fears of cosmic radiation. Some of the animals sent aloft were exposed to cosmic particles above 90,000 feet for as long as 35 hours. One balloon attained an altitude of 120,000 ft.

Of particular importance in these experiments was the effect of cosmic particles upon the central nervous system, because dead nerves are not replaceable. If the particles did damage or destroy nerve cells, the performance of the exposed individual may be hindered.

Monkeys were sent aloft and exposed to cosmic radiation and their performances were observed closely before and after the balloon flights. The monkeys performed normally after their two flights. After watching the exposed animals for six months following the experiments, it is tentatively concluded that cosmic particles may have been overestimated as hazards to the nerve system and that a traveller in the stratosphere should be able to perform duties in a normal manner with no serious after-effects.

It had been feared also that cosmic radiation might cause cataracts to form on the eyes. For this experiment albino mice were used because of their supersensitive eyes. After being exposed to radiation, no cataracts were observed in the eyes of the mice.

Other flights indicated that none of the specimens lost hair or suffered permanent injuries from exposure to primary cosmic radiation, except that black rats incurred some damage to hair follicle pigment cells causing the affected cells to produce white hair. This was the only experiment which indicated that a test subject had been affected by exposure to cosmic radiation.

There were no results from the experiments indicating that cosmic radiation has any biological effect which cannot be explained on the basis of available physical description of radiation at these altitudes.

None of the experiments evaluating physical and mental functions showed adverse conditions as a result of being exposed to cosmic rays.

From results gathered on the body systems test, it appears that the biological effects of cosmic particles are no greater than the minimum values expected, except for the positive results on hair greying.

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Sky Diary: January to March, 1958

By A. E. SLATER

We have come round to the first anniversary of "Sky Diary," and so has that conspicuous feature of the winter sky—a great collection of bright stars in the south, comprising Orion and its neighbouring constellations, depicted by Patrick Moore in *Spaceflight* No. 2 (Jan. 1957, p. 86).

To the left of Orion and a little below is the Dog Star Sirius, the brightest star in the sky. It is not generally realized that Sirius makes an excellent clock, because at the beginning of the year it is due south at midnight; you only have to allow for it reaching this position two hours earlier each month (or about half an hour earlier each week), and for its daily motion round the sky at 45 degrees per three hours. Thus:—

POSITION OF SIRIUS

	S.E.	S.	S.W.
January 2	9 p.m.	midnight	3 a.m.
February 1	7 p.m.	10 p.m.	1 a.m.
March 3	5 p.m.	8 p.m.	11 p.m.
April 3	—	6 p.m.	9 p.m.

The variations in date are due to variations in the length of the months, but eye estimates are not accurate enough for the precise date to matter.

To find the south point if you don't know it already, stand with your back to the Pole Star (to identify it, see map, *Spaceflight* No. 3, April, 1957, p. 120), tilt your head back till you see it (for this exercise the balancing organs of the inner ear should be in full working order), then draw an imaginary line from the Pole Star to the overhead point and continue it till it meets the southern horizon.

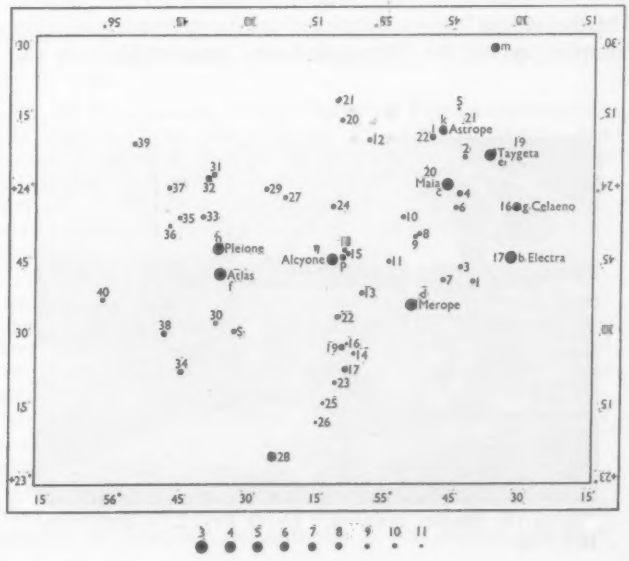
This method of telling the time is of no use during a space voyage, so I have already broken my resolution to put nothing into "Sky Diary" unless it has astronautical implications. So let it be added, in case interstellar travel ever becomes feasible, that Sirius is 8·6 light-years distant—only about twice as far as the nearest star. It has a companion 22,000 miles in diameter, but this is no planet; it is a highly compressed star, weighing a ton to the cubic inch by earthly standards, and it and Sirius revolve round their common centre of gravity once every 50 years. Imagine visiting this pair in search of planetary life, finding (perhaps) that they share a planet in common, and trying to predict its orbit and the most economical course for reaching it!

To the right and above Orion is a reddish star, Aldebaran, and then, further along the same direction, a cluster of stars called the Pleiades which, once seen, are easily recognized ever after. Six of the stars can be easily picked out by eye, often seven, and acute vision may detect more, while a telescope may reveal hundreds. The diagram shows the names given to the brighter ones. Alcyone, the brightest, of third magnitude, is under suspicion of having been much fainter in Ptolemy's time.

The Pleiades form a genuine group, for they all move together across the star background at rather less than 10 seconds of arc per century. Alongside a picture of the Pleiades in Ball's *Popular Guide to the Heavens*, given me at the age of nine, is a statement in childish handwriting that they are 250 light-years away; but the source of this information has been forgotten. Anyway, with a little simple trigonometry one finds that the group of brighter stars is just over four light-years across.

If our Solar System, instead of being part of a "local group" which includes the bright stars of Orion and its neighbours, had come into existence in the very centre of the Pleiades—say, a quarter of a light-year from Alcyone, then that star would be a thousand times nearer and consequently look a million times ($1{,}000^2$) as bright as it does from where we are now. So its stellar magnitude, instead of being plus 3, would be minus 12, which is precisely the brightness of the Moon. What with a lot of other stars only a few magnitudes fainter, and bright wisps of nebula spanning the sky (we cannot see them from our present position except in photographs), there would be no dark nights for any planet in the Pleiades.

If anyone tells you that the crescent New Moon "on its back" is a sign of rain, say that you can predict thousands of years ahead when the New Moon is going



to "lie on its back", because it always happens in February and March, when the line from Sun to Moon goes steeply up from the western horizon. The weather, on the other hand, often cannot be predicted for a thousand minutes ahead, especially in February and March. Probably you will convince nobody, for reason is powerless against superstition. But imagine trying to establish a human colony on a Moon which is liable to tip over sideways whenever a depression is to be seen approaching the British Isles!

The Moon is going to be of use for weather forecasting when, and not before, a television station is established on it for broadcasting views of the cloud systems over the Earth.

Venus is at first an evening star, showing a thin crescent through a telescope, but passes this side of the Sun on January 29 and is thereafter a morning star. Mars and Saturn are also morning stars, seen in the east before sunrise. Jupiter, however, comes up about midnight at the beginning of the period, and thereafter earlier as time goes on, but is not in opposition till April.

Uranus, in opposition at the end of January, should be just visible to the eye; it will then be about 1½ degrees to the left of the 4th magnitude star Delta in Cancer (see any star chart), which it passes half a degree to the northward in March. So it can be recognized by its motion, if by nothing else, though the ancients never noticed it. Why not take this chance to get one up on those ancients?

The Fall of the Sputnik Launcher

As was expected, the third stage of the vehicle which launched Sputnik I into its orbit fell long before the satellite itself showed any imminent signs of doing so. It seems to have made 878 complete circuits of the Earth, and to have failed to complete its 879th. The date of the fall was December 1, 1957.

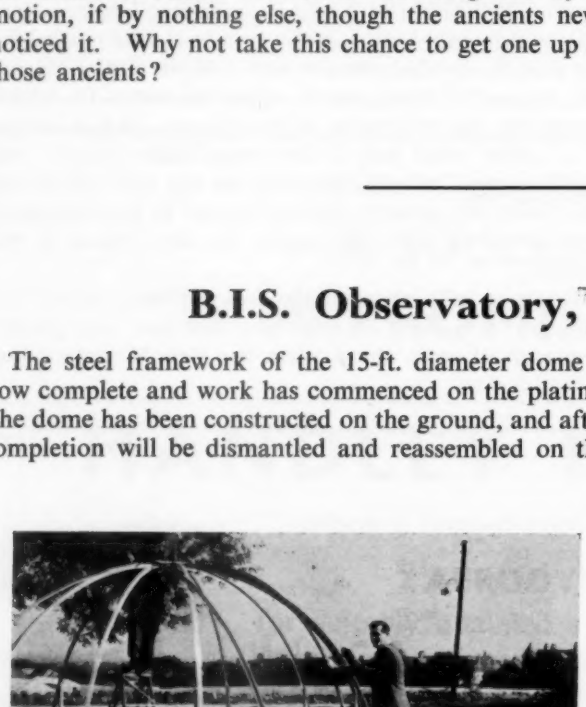
There are no reliable reports of the descent; the launcher simply failed to appear at the usual time, and this caused no surprise, as earlier statements had made it clear that its lifetime was very limited. The first official Russian comments were made by Mr. Khruschev at a reception at the Finnish Embassy in Moscow, in which it is reported that he claimed the rocket to have fallen on American territory. Prof. Lovell, from the Jodrell Bank radio observatory, stated that "at the week-end we concluded that the rocket of the first Sputnik came down early on December 1 . . . the Russian statement is entirely in accordance with our conclusions."

There is no confirmation that the rocket landed on American soil, and in fact no confirmation that it landed intact—or even damaged. It is widely believed that if any of the launcher survived the fall, it landed in the Pacific; but nobody really knows, and it seems improbable that anybody ever will.

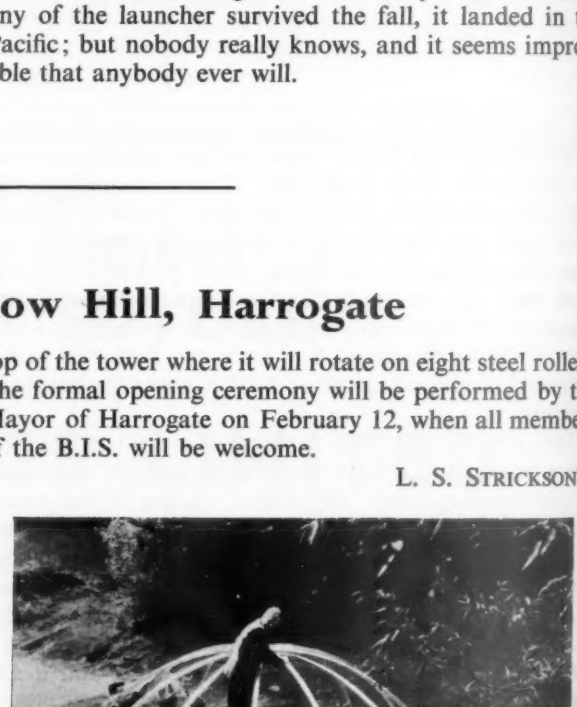
B.I.S. Observatory, Harlow Hill, Harrogate

The steel framework of the 15-ft. diameter dome is now complete and work has commenced on the plating. The dome has been constructed on the ground, and after completion will be dismantled and reassembled on the top of the tower where it will rotate on eight steel rollers. The formal opening ceremony will be performed by the Mayor of Harrogate on February 12, when all members of the B.I.S. will be welcome.

L. S. STRICKSON



Fixing the shutter opening. Derek Fry, L. S. Strickson, B. Clegg



IT ALL FITS! M. Greenwood, B. Clegg, L. S. Strickson, Col. G. E. B. Stephenson

Reviews

Once Round the Sun. By Ronald Fraser. Hodder and Stoughton (London), 1957. 160 pp.

Although this is not a book concerned directly with astronautics, except for the last chapter, it will undoubtedly interest the readers of this journal. The title refers to the period of time called the International Geophysical Year, and the book is subtitled "The Story of the I.G.Y. 1957–58." The author, Dr. Ronald Fraser, is the Administrative Secretary of the International Council of Scientific Unions, which is the body sponsoring the I.G.Y., and can therefore write with authority on the project.

The book is divided into two sections, the first of which is called "On the boundaries of the known world". In this first part (74 pages), the author deals with the questions we can ask about the physical environment in which we live. The object of doing this is to give the reader the background knowledge against which to view the various activities of the I.G.Y. teams, and to help him to understand the reasons for the many and diverse methods of investigation to be used. In this, the author succeeds admirably, and in a small number of pages covers a wide range of topics in a simple and stimulating manner. His first chapter deals with the earth, and introduces a number of facts about the behaviour of the earth and its atmosphere as a dynamical system which are not well known, such as the resonance of the atmosphere, the two magnetic fields of the earth, and the electrical properties of the earth's core. The next chapter deals with weather and here we have a detailed description of the wind systems and their possible causes. Currents, waves and tides are next described, and some of the problems which will be investigated are mentioned. The properties of the outer atmospheric layers are discussed in the next chapter. A description of the chemistry of the atmosphere leads to a discussion of its electrical properties and the propagation of electromagnetic waves. Since most of the phenomena considered in the first four chapters are related to the action of the Sun, sunspots and solar flares are next dealt with. In this chapter we learn how conditions at the surface of the Earth are governed by the electromagnetic and corpuscular radiations received from the Sun. This concludes the first part of the book, and we are left with a good idea of the boundaries of present-day knowledge about our planet and can therefore, as Dr. Fraser intended, appreciate the second portion of the book, which deals with the actual organization of the I.G.Y. and how it is hoped to cross some of these boundaries in the near future.

This first portion of the book is written with considerable imagination and makes interesting reading. The second part, called "Towards new horizons", which discusses what we hope to achieve from the I.G.Y., is unfortunately not always so stimulating. This is mainly because the author has tried to be fair to everyone taking part in the I.G.Y. activities, and has therefore had to include too much, so that we get the impression that we are reading a catalogue of proposed activities and tend to become saturated with too many details.

The first chapter of part 2 covers the I.G.Y. organization and describes how the original idea evolved. There is a rather humorous assessment of the Royal Society on page 100. "The National Academy of the United States can tap the vast scientific potential of North America, the Académie des Sciences de Paris can recruit the unbreakable genius of France, the Royal Society of London can still squeeze funds out of the British Treasury for a worthy object. . . ."

Chapter 7 describes the Antarctica expeditions to be made, or which are now under way; dealing with the activities of each country in turn. It is interesting to learn that the Commonwealth expedition, which has received considerable publicity compared with some of the other expeditions . . . "will be fun to watch, it may even be glorious, but it is only very incidentally geophysics". Chapter 8 deals with the way in which the I.G.Y. organizers have divided the scheme of work into ten sections, and how these sections will interlock in the I.G.Y. schedule. Chapter 9, which is the penultimate chapter, deals with rockets and satellites. Through no fault of the author, much of this chapter is now dated. The first few pages describe the uses to which rockets and satellites will be put. Most of this will be familiar to the reader, and has been dealt with better elsewhere. The rest of the chapter deals with satellites, and almost exclusively with the American proposals. The various statements made about satellite life times in different orbits, and so on, we now know to be incorrect. Never before, probably, has part of a book been made so thoroughly out of date so quickly. This does not detract from the value of the book, however, as it only applies to 10 pages; in fact it tends to make the book more interesting in that the Russian achievement underlines the success of the organization the book sets out to describe.

This book can be highly recommended in that the author succeeds in giving the non-specialist a good background against which to view the I.G.Y. activities as the results come in, and here the term non-specialist includes all of us, since no-one can be a specialist in all the topics covered by Dr. Fraser. The book is well produced and contains many interesting diagrams and photographs. As the official story of what is probably the largest scientific undertaking ever to be started, it can only gain in interest as the I.G.Y. activities progress, and although the scientific parts may become dated as time goes on, such an occurrence is a measure of the success of the I.G.Y. and will tend to enhance the interest of the book.

N. H. LANGTON

Discovery of the Universe. By Gerard de Vaucouleurs. Faber and Faber, London, 1957. 328 pp. Price £1 10s.

Dr. de Vaucouleurs, the distinguished French astronomer, now carrying out research in the United States, has written a popular history of astronomy, beginning with its "origins" and ending with the most recent developments. Very wisely, he has devoted most of his pages to comparatively modern times, and his book contains a great deal of valuable information.

The book is free from important misprints and inaccuracies; it is in fact wholly reliable apart from the usual mistakes such as the wrong spelling of Edmond Halley's name, and the repetition of the old but quite unfounded story that Newton's researches were delayed because he was using an incorrect value for the radius of the Earth. Those who are interested in any aspect of astronomy will do well to purchase it. The price is not inordinately high in view of the excellent print, paper, and photographs.

Two criticisms only can be made. One is that the translation is far from flawless; it is inclined to be stilted and awkward, so that one suspects that it was carried out by a

writer who is more accustomed to the French language. The other criticism is that in a book of this nature, it is quite deplorable that the author should have included an appendix (pp. 309–313) criticizing other books which cover the same ground. In any future edition, this appendix should be deleted, and replaced by a straightforward list of recommended books.

Despite these two flaws, the book is certainly one of the best histories of astronomy to appear in recent years.

K. E. S.

The Universe and Dr. Einstein. By Lincoln Barnett. Collins Comet Books, 1957. 124 pp. 2s. 6d.

One of the problems facing the modern reader is that of constantly rising book prices. It is therefore very satisfactory to see that the paper-backed book under review sells at only half-a-crown, and is nevertheless excellently printed and produced. The original edition appeared in 1949, and four more impressions appeared between 1950 and 1955.

The book presents the elements of relativity theory in a sensible, understandable manner. Mathematics are almost completely excluded, and in consequence the whole text can be followed by a reader who has no specialized knowledge. Obviously, the scope of the book is limited; but within these limits, it is difficult to quarrel with anything which the author has written. The book may be recommended as a particularly good attempt to interpret relativity to the non-scientific reader. There is a Foreword by Dr. Einstein himself.

It is announced that several other scientific books are to appear in this new "Comet" series, such as Moore's *Guide to the Moon* and *Guide to the Planets*. The publishers are to be congratulated upon the venture; may we soon hope for a "Comet" book devoted specifically to interplanetary matters?

R. H. WESSON.

Space Encyclopædia. Edited by M. T. Bizony. Artemis Press. 287 pp. Numerous photographs and drawings. 35s.

This is a book for which many people have been waiting; a full, though popular, encyclopædia of Astronomy and Astronautics. The entries are arranged in alphabetical order, and every aspect is covered. The authors are experts in their various fields; four astronomers (Sir Harold Spencer Jones, the former Astronomer Royal; Dr. R. H. Garstang; Patrick Moore, and Dr. J. G. Porter), a radio astronomer (Professor A. C. B. Lovell), a biologist (Dr. Hubertus Strughold), a physicist (Homer E. Newell), and a writer on rockets (E. Burgess). Articles have also been contributed by the editor, M. T. Bizony, and the assistant editor, R. Griffin.

The print and presentation leave nothing to be desired; the illustrations are most excellent, ranging from clear line diagrams-to first-class astronomical photographs and pictures of modern rockets; and there are various useful items, such as a good small-scale map of the Moon, and a cross-sectional diagram of the atmosphere. Nor, in general, can one fault the articles themselves. Anyone who reads through the book will assimilate a sound groundwork of astronomical and rocket knowledge, while even the technician will want to keep the book upon his shelves for handy reference. If you want to look up the exact meaning of Nutation, to refer to a list of yearly meteor showers, to refresh your memory about Operation Vanguard, or to read a summary of known facts about the planet Mars—you will find in this book everything that is necessary.

There are, however, three points of criticism. One concerns the article on space-stations, written by M. T. Bizony himself. Here is an instance—perhaps the only one in the book—of bias; the author has no faith in space-stations, and says so, dogmatically and unwisely. Personal views of this sort are out of place in an encyclopædia. The second criticism is that it seems unnecessary to include data upon some special rockets which are already obsolete; this "dates" the book, and it would have been better to confine this section to principles and to certain rockets of permanent and historical interest, such as the A-4. The third point is that the reviewer has detected a number of cases of misprints, indicating that the proof-reading was not carried out with sufficient care; for instance, on page 103 the escape velocity of Jupiter is given as 60 miles/sec. instead of 37, though the value is correctly given in the article on "Jupiter" on page 144. All the slips are minor, but they should not have occurred.

However, the reviewer has no doubt that this book will run to many editions, and there is every likelihood that it will become recognized as a standard of reference, so that the weak points listed above can be put right in the next printing. Enough has been said to show that *Space Encyclopædia* is a book which every enthusiast ought to possess.

W. J.

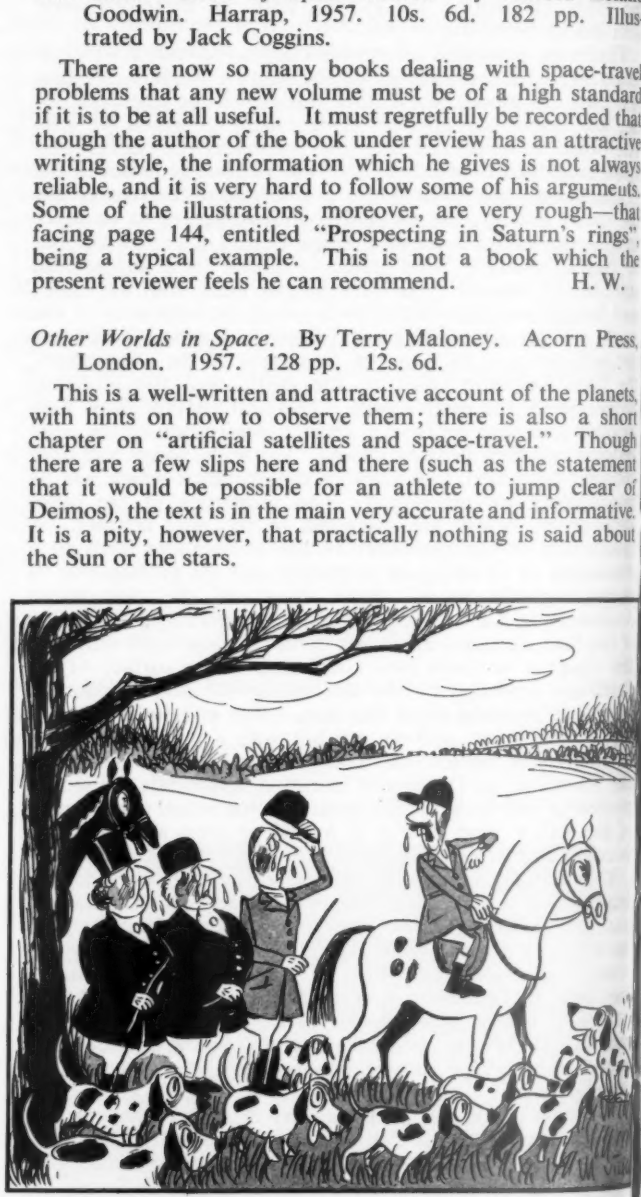
The Science Book of Space Travel. By Harold Leland Goodwin. Harrap, 1957. 10s. 6d. 182 pp. Illustrated by Jack Coggins.

There are now so many books dealing with space-travel problems that any new volume must be of a high standard if it is to be at all useful. It must regretfully be recorded that though the author of the book under review has an attractive writing style, the information which he gives is not always reliable, and it is very hard to follow some of his argumeuts. Some of the illustrations, moreover, are very rough—that facing page 144, entitled "Prospecting in Saturn's rings", being a typical example. This is not a book which the present reviewer feels he can recommend.

H. W.

Other Worlds in Space. By Terry Maloney. Acorn Press, London. 1957. 128 pp. 12s. 6d.

This is a well-written and attractive account of the planets, with hints on how to observe them; there is also a short chapter on "artificial satellites and space-travel." Though there are a few slips here and there (such as the statement that it would be possible for an athlete to jump clear of Deimos), the text is in the main very accurate and informative. It is a pity, however, that practically nothing is said about the Sun or the stars.



"Well, that's the end of our two-minutes silence in honour of poor little Laika . . . TALLY-HO!"

Reproduced by courtesy of the Daily Mirror

The most outstanding feature of the book is its beautiful drawings, by the author himself. These range from telescopic views of the planets, to "imaginative" surface pictures, and rank with the best that the present reviewer has ever seen. C. M.

Instructions to Young Astronomers. By H. P. Wilkins. Museum Press, London. 1957. 128 pages. 10s. 6d.

The title of this book is rather unfortunate, as it gives the impression of a forbidding, dryly-written volume. In point of fact it is nothing of the kind, and the young enthusiast will find a great deal to interest him. The author has managed to impart much information without any effect of "cramming"; there are plenty of illustrations, and innumerable useful hints for the beginner. Really good astronomical books for young people are not so common as is often thought. Dr. Wilkins has provided one, and his aim of presenting an instructive and readable volume has been admirably achieved. K. E. S.

Man Unlimited. By Heinz Gartmann. Jonathan Cape. 18s.

In *Man Unlimited* Dipl. Ing. Gartmann seeks to bring into perspective the position of the relatively frail human structure when compared with the increasingly terrifying machines which man's ingenious mind is forever creating.

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OTHER RECENT BOOKS

(Mention in this list does not preclude subsequent review.)

Space Research and Exploration. D. R. Bates (Editor). Eyre & Spottiswoode, London, 1957.

Satellites and Spaceflight. E. Burgess. Chapman & Hall, London, 1957.

The Amateur Astronomer. Patrick Moore. Lutterworth Press, London, 1957.

Man into Space. Hermann Oberth. Weidenfelt & Nicolson, London, 1957.

The Inhabited Universe. K. W. Gatland. Wingate, London, 1957.

Satellite! E. Bergaust and W. Beller. Lutterworth Press, London, 1957.

Guide to the Planets. Patrick Moore. Collins Comet Books, London, 1957.

Space Flight and Satellite Vehicles. R. B. Beard and A. C. Rotherham. Newnes, 1957.

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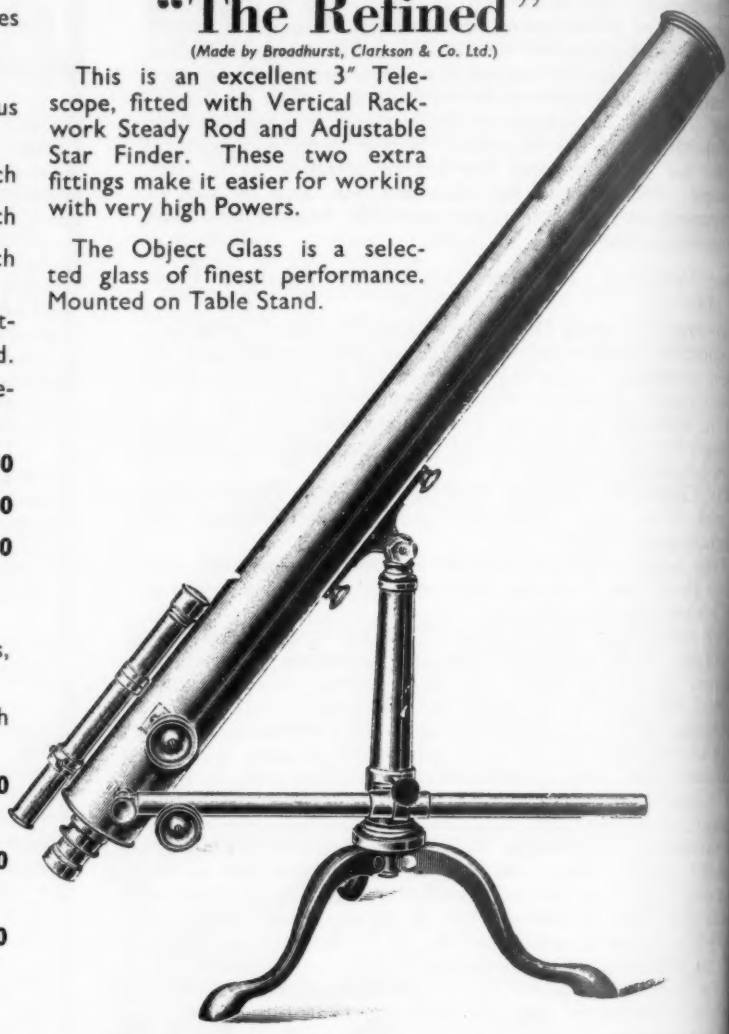

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